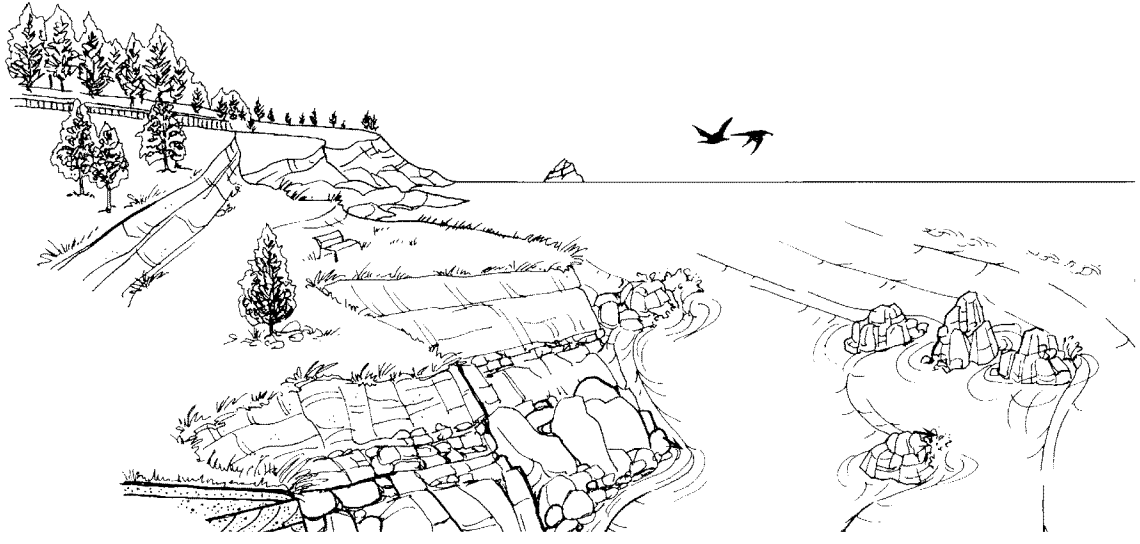
Characteristic Coastal Habitats

Choosing Spill Response Alternatives



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service
Office of Response and Restoration
Emergency Response Division

Revised 2010
Reprinted March 2013

Characteristic Coastal Habitats:
Choosing Spill Response Alternatives

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Seattle, Washington

Characteristic Coastal Habitats: Choosing Spill Response Alternatives was originally based upon information contained in *Environmental Considerations for Marine Oil Spill Response* by the American Petroleum Institute, the National Oceanic and Atmospheric Administration, the U.S. Coast Guard, and the U.S. Environmental Protection Agency. The original printing was in 2000, NOAA revised the document in 2010.

CONTENTS

Introduction

Oil on coastal waters, shorelines, or subtidal habitats can harm the environment, intrude on recreational activities, cause economic hardship, disrupt commercial activities, and be expensive to clean up. Decisions about if, where, when, and how to remove oil from coastal habitats affect each of these potential spill consequences.

Sound cleanup decisions depend on accurate information about the types of habitats that the oil affects, the degree of oiling, and the location of oiling. *Characteristic Coastal Habitats* illustrates typical physical and biological attributes of North American coastal habitats at risk from oil spills. The text describes each habitat and discusses both how oil is likely to behave there and considerations for treating oil.

The *Characteristic Coastal Habitats* collection was originally designed as a companion to *Environmental Considerations for Marine Oil Spill Response*, published in 2001 by the American Petroleum Institute, the National Oceanic and Atmospheric Administration, the U.S. Coast Guard, and the U.S. Environmental Protection Agency (although this document is not readily available as of 2009). The Response Method table for each habitat is based on information contained in the *NOAA Shoreline Assessment Manual* and the job aid entitled *Characteristics of Response Strategies – A Guide for Spill Response Planning in Marine Environments*. Refer to these publications for complete information on proper use and caveats regarding the guidelines presented in the Response Method tables.

In April 2010, NOAA revised this version of the *Characteristic Coastal Habitats* to reflect the current knowledge on oil spill behavior and impacts of response options.

The *Characteristic Coastal Habitats* collection is a useful job aid for training people who will be participating in cleanup assessment as part of an Environmental Unit within the Incident Command System. It also complements NOAA's *Shoreline Assessment Manual* and *Shoreline Assessment Job Aid*. Visit the Office of Response and Restoration's home page at http://response.restoration.noaa.gov for copies of the manual and job aid. *Characteristic Coastal Habitats* is available in a digital version at this website.

How to use this document

This document summarizes the technical rationale for selecting response methods for four categories of oil in specific habitats. As a companion to *Environmental Considerations for Marine Oil Spill Response*, *Characteristic Coastal Habitats* can help you select appropriate response options to minimize the adverse environmental impacts of a marine oil spill. The guide discusses intertidal, subtidal, ice, and on-water habitats. Specific response options include natural recovery; mechanical, chemical, and biological treatment; and in-situ burning.

When choosing effective response options, including natural recovery, you must consider trade-offs affecting the option's potential environmental impact, its appropriateness for the habitat, and timing of its application. *Environmental Considerations for Marine Oil Spill Response* discusses these considerations in detail; you may wish to consult it and other documents such as the *NOAA Shoreline Assessment Manual* (2009), *Oil Spills in Coral Reefs* (2003), and *Oil Spills in Mangroves* (2007), before using this guideline. Remember that the benefits and impacts of response options depend upon incident-specific conditions and affect the suitability of the option for use in a habitat during any spill. For example, dove-tailing multiple methods simultaneously throughout an incident might produce a more effective response and fewer adverse environmental impacts.

Each section of this guide includes information about methods currently in use during oil spill responses in marine environments. The two tables following this section present information on the relative environmental impact of methods in the absence of oil for each habitat. These tables will help you understand the impact of a response option independent of oil effects. Following this section is the Habitat section with descriptions of intertidal, shallow subtidal, ice, and on-water habitats. For each of the four habitat categories there is a picture, a description of the habitat type, and a table describing the relative impact of the different response methods to the environment for different oil types. These tables will help you understand the impact of the response option and oil together for each habitat.

The following categories are used to compare the relative environmental impact of each response method in a specific environment and habitat. The codes in each table mean:

A = The least adverse habitat impact.
B = Some adverse habitat impact.
C = Significant adverse habitat impact.
D = The most adverse habitat impact.
I = Insufficient information - impact or effectiveness of the method could not be evaluated.
– = Not applicable.

Response Method	Exposed Rocky Shores	Exposed Solid Man-made Structures	Exposed Wave-cut Platforms	Sand Beaches	Tundra Cliffs	Mixed Sand and Gravel Beaches	Gravel Beaches	Riprap	Exposed Tidal Flats
Natural Recovery	A	A	A	A	A	A	A	A	A
Booming	–	–	–	–	–	–	–	–	–
Skimming	–	–	–	–	–	–	–	–	–
Barriers/Berms	–	–	–	B*	D	B*	C	–	C
Physical Herding	–	–	–	–	–	–	–	–	B
Manual Oil Removal/Cleaning	B	B	B	B	D	B	B	A	C
Mechanical Oil Removal	–	–	–	C*	D	C*	C	C	C
Sorbents	B	B	B	B	C	B	B	A	B
Vacuum	B	–	B	B	D	B	B	A	B
Debris Removal	B	–	B	B	A	B	B	A	B
Sediment Reworking/Tilling	–	–	–	C*	D	C*	C	–	C
Vegetation Cutting/Removal	–	–	–	C*	D	C*	–	–	D
Flooding (deluge)	–	–	B	B	C	B	B	B	B

This table provides information on the relative environmental impacts of response methods in the absence of oil in shoreline intertidal and ice environments.

* - Special biological need consideration - if birds and turtles are nesting, the ranking would be "D."

Note: Table continues on pages 7–9

ENVIRONMENTAL IMPACTS IN THE ABSENCE OF OIL: Shoreline Intertidal and Ice Environments

Response Method	Sheltered Rocky Shores & Scarps	Sheltered Solid Man-made Structures	Peat Shores	Sheltered Tidal Flats	Marshes	Mangroves	Inundated Lowland Tundra	Accessible Ice	Inaccessible Ice
Natural Recovery	A	A	A	A	A	A	A	A	A
Booming	–	–	–	–	–	–	–	B	–
Skimming	–	–	–	–	–	–	–	B	–
Barriers/Berms	–	–	–	C	C	C	–	B	–
Physical Herding	–	–	–	–	–	–	–	B	–
Manual Oil Removal/Cleaning	B	B	B	C	C	C	D	B	–
Mechanical Oil Removal	–	–	D	–	D	–	D	B	–
Sorbents	B	A	B	B	C	C	C	B	–
Vacuum	B	–	B	B	C	C	D	B	–
Debris Removal	B	A	B	C	C	C	D	B	–
Sediment Reworking/Tilling	–	–	B	–	D	–	–	–	–
Vegetation Cutting/Removal	D	–	C	D	D	–	D	–	–
Flooding (deluge)	B	–	B	B	B	B	C	–	–

ENVIRONMENTAL IMPACTS IN THE ABSENCE OF OIL: Shoreline Intertidal and Ice Environments

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat. The codes in each table mean:

A = The least adverse habitat impact.
B = Some adverse habitat impact.
C = Significant adverse habitat impact.
D = The most adverse habitat impact.
I = Insufficient information - impact or effectiveness of the method could not be evaluated.
– = Not applicable.

Response Method (cont.)	Exposed Rocky Shores	Exposed Solid Man-made Structures	Exposed Wave-cut Platforms	Sand Beaches	Tundra Cliffs	Mixed Sand and Gravel Beaches	Gravel Beaches	Riprap	Exposed Tidal Flats
Low-pressure, Ambient Water Flushing	B	B	B	B*	D	B*	B	B	C
High-pressure, Ambient Water Flushing	C	C	C	–	–	C*	C	C	–
Low-pressure, Hot Water Flushing	D	D	D	D	–	D	D	D	–
High-pressure, Hot Water Flushing	D	D	D	–	–	D	D	D	–
Steam Cleaning	D	D	D	–	–	D	D	D	–
Sand Blasting	D	D	D	–	–	–	–	D	–
Dispersants	–	–	–	–	–	–	–	–	–
Emulsion-treating Agents	–	–	–	–	–	–	–	–	–
Elasticity Modifiers	–	–	–	–	–	–	–	–	–
Herding Agents	–	–	–	–	–	–	–	–	–
Solidifiers	–	–	B	B	C	B	B	B	B
Shoreline Cleaning Agents	B	B	B	–	–	C*	B	B	–
Nutrient Enrichment	–	–	–	B	C	B	B	B	C
Natural Microbe Seeding	–	–	–	I	I	I	I	I	I
In-situ Burning	–	–	D	C	–	C	C	D	–

This table provides information on the relative environmental impacts of response methods in the absence of oil in shoreline intertidal and ice environments.

* - Special biological need consideration - if birds and turtles are nesting, the ranking would be "D."

ENVIRONMENTAL IMPACTS IN THE ABSENCE OF OIL: Shoreline Intertidal and Ice Environments

Response Method	Sheltered Rocky Shores & Scarps	Sheltered Solid Man-made Structures	Peat Shores	Sheltered Tidal Flats	Marshes	Mangroves	Inundated Lowland Tundra	Accessible Ice	Inaccessible Ice
Low-pressure, Ambient Water Flushing	B	B	B	C	B	B	D	B	–
High-pressure, Ambient Water Flushing	C	C	–	–	–	–	–	–	–
Low-pressure, Hot Water Flushing	D	D	–	–	–	–	–	B	_
High-pressure, Hot Water Flushing	D	D	–	–	–	–	–	–	–
Steam Cleaning	D	D	–	–	–	–	–	B	_
Sand Blasting	D	D	–	–	–	–	–	–	–
Dispersants	–	–	–	–	–	–	–	B	_
Emulsion-treating Agents	–	–	–	–	–	–	–	B	_
Elasticity Modifiers	–	–	–	–	–	–	–	B	_
Herding Agents	–	–	–	–	–	–	–	B	–
Solidifiers	B	–	–	C	C	C	C	B	_
Shoreline Cleaning Agents	B	B	–	–	B	I	–	–	–
Nutrient Enrichment	B	–	B	I	B	I	I	I	I
Natural Microbe Seeding	I	–	I	I	I	I	I	I	I
In-situ Burning	D	–	–	–	C	–	D	B	–

ENVIRONMENTAL IMPACTS IN THE ABSENCE OF OIL: On-water and Shallow Subtidal Environments

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat. The codes in this table mean:

A = The least adverse habitat impact.
B = Some adverse habitat impact.
C = Significant adverse habitat impact.
D = The most adverse habitat impact.
I = Insufficient information - impact or effectiveness of the method could not be evaluated.
– = Not applicable.

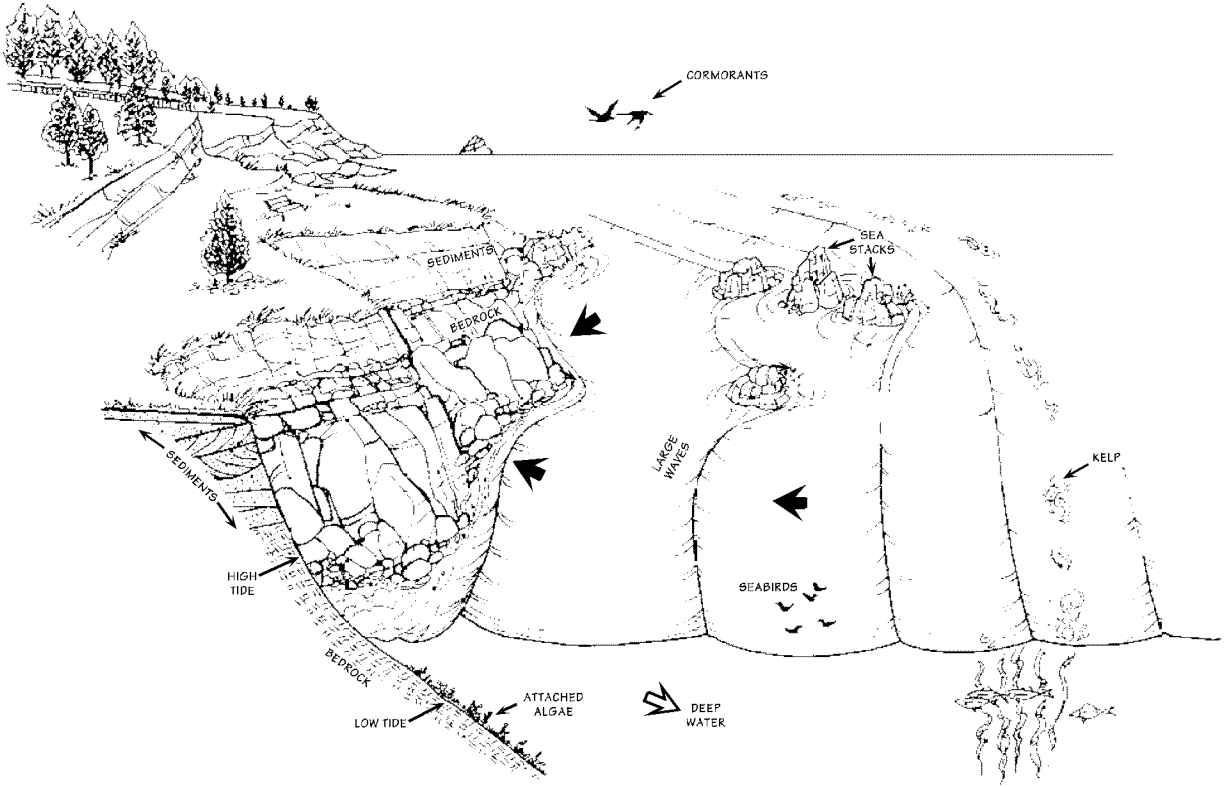
Response Method	Offshore	Bays and Estuaries	Coral Reefs	Seagrasses	Kelp	Soft Bottom	Mixed and Hard Bottom
Natural Recovery	A	A	A	A	A	A	A
Booming	A	B	C	B	B	A	A
Skimming	A	B	B	B	B	A	A
Barriers/Berms	–	–	–	–	–	–	–
Physical Herding	B	B	B	B	B	B	B
Manual Oil Removal/Cleaning	–	B	D	C	B	B	C
Mechanical Oil Removal	–	–	D	D	D	C	–
Sorbents	A	B	C	B	B	B	C
Vacuum	–	–	C	C	B	B	C
Debris Removal	B	B	B	B	B	B	B
Sediment Reworking/Tilling	–	–	–	–	–	–	–
Vegetation Cutting/Removal	–	–	–	C	C	–	–
Flooding (deluge)	–	–	–	–	–	–	–

This table provides information on the relative environmental impacts of response methods in the absence of oil in on-water and shallow subtidal environments.

ENVIRONMENTAL IMPACTS IN THE ABSENCE OF OIL: On-water and Shallow Subtidal Environments

Response Method (cont.)	Offshore	Bays and Estuaries	Coral Reefs	Seagrasses	Kelp	Soft Bottom	Mixed and Hard Bottom
Low-pressure, Ambient Water Flushing	–	–	B	–	–	–	–
High-pressure, Ambient Water Flushing	–	–	–	–	–	–	–
Low-pressure, Hot Water Flushing	–	–	–	–	–	–	–
High-pressure, Hot Water Flushing	–	–	–	–	–	–	–
Steam Cleaning	–	–	–	–	–	–	–
Sand Blasting	–	–	–	–	–	–	–
Dispersants	B	B	D	D	D	C	C
Emulsion-treating Agents	B	B	I	I	I	I	I
Elasticity Modifiers	B	B	C	C	I	I	I
Herding Agents	B	B	C	C	I	I	I
Solidifiers	B	B	C	C	I	I	I
Shoreline Cleaning Agents	–	–	–	–	–	–	–
Nutrient Enrichment	–	–	–	–	–	–	–
Natural Microbe Seeding	–	–	–	–	–	–	–
In-situ Burning	B	B	B	B	C	B	B

INTERTIDAL: Exposed Rocky Shores



Description

- The intertidal zone is steep (>30° slope) and narrow with very little width.
- Sediment accumulations are uncommon because waves remove debris that has slumped from the eroding cliffs.
- There is strong vertical zonation of intertidal biological communities.
- Species density and diversity vary greatly, but barnacles, snails, mussels, polychaetes, and macroalgae can be abundant.

Predicted Oil Behavior

- Oil is held offshore by waves reflecting off the steep, hard surfaces.
- Any oil that is deposited is rapidly removed from exposed faces.
- The most resistant oil would remain as a patchy band at or above the high-tide line.
- Impacts to intertidal communities are expected to be short-term. An exception would be where heavy concentrations of a light refined product came ashore very quickly.

Response Considerations

- Cleanup is usually not required.
- Access can be difficult and dangerous.

INTERTIDAL: Exposed Rocky Shores

Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

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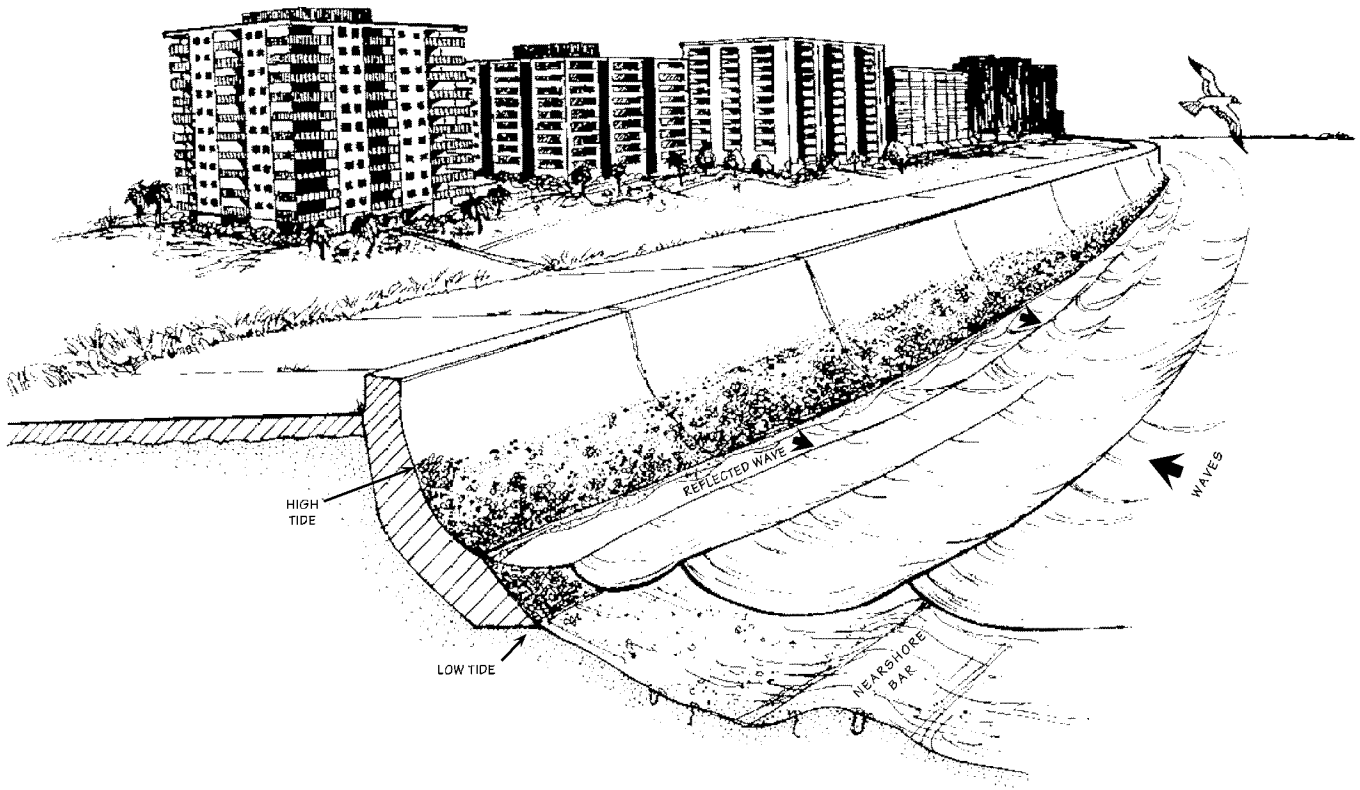
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	A	A	A
Barriers/Berms	–	–	–	–	–
Manual Oil Removal/Cleaning	–	–	B	B	B
Mechanical Oil Removal	–	–	–	–	–
Sorbents	–	B	A	A	A
Vacuum	–	A	A	A	A
Debris Removal	–	A	A	A	A
Sediment Reworking/Tilling	–	–	–	–	–
Vegetation Cutting/Removal	–	–	C	C	C
Flooding (deluge)	–	–	–	–	–
Low-pressure, Ambient Water Flushing	–	A	A	B	B
High-pressure, Ambient Water Flushing	–	B	B	B	B
Low-pressure, Hot Water Flushing	–	–	C	C	C
High-pressure, Hot Water Flushing	–	–	C	C	C
Steam Cleaning	–	–	D	D	–
Sand Blasting	–	–	D	D	D
Solidifiers	–	–	–	–	–
Shoreline Cleaning Agents	–	–	C	C	C
Nutrient Enrichment	–	–	–	–	–
Natural Microbe Seeding	–	–	–	–	–
In-situ Burning	–	–	–	–	–


HIGH TIDE
LOW TIDE
REFLECTED WAVE
WAVES
NEARSHORE BAR

INTERTIDAL: Exposed, Solid Man-made Structures

Description

- These are solid, man-made structures such as seawalls, groins, revetments, piers, and port facilities.
- Many structures are constructed of concrete, wood, or metal.
- They are built to protect the shore from erosion by waves, boat wakes, and currents, and thus are exposed to rapid natural removal processes.
- Often there is no exposed substrate at low tide, but multiple habitats may be present.
- Attached animals and plants are sparse to common.

Predicted Oil Behavior

- Oil is held offshore by waves reflecting off the steep, hard surfaces in exposed settings.
- Oil readily adheres to the dry, rough surfaces, but it does not adhere to wet substrates.
- The most resistant oil would remain as a patchy band at or above the high-tide line.

Response Considerations

- Cleanup is usually not required.
- High-pressure water spraying may be conducted to remove risks of contamination of people or vessels or to improve aesthetics.

Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in this table mean:

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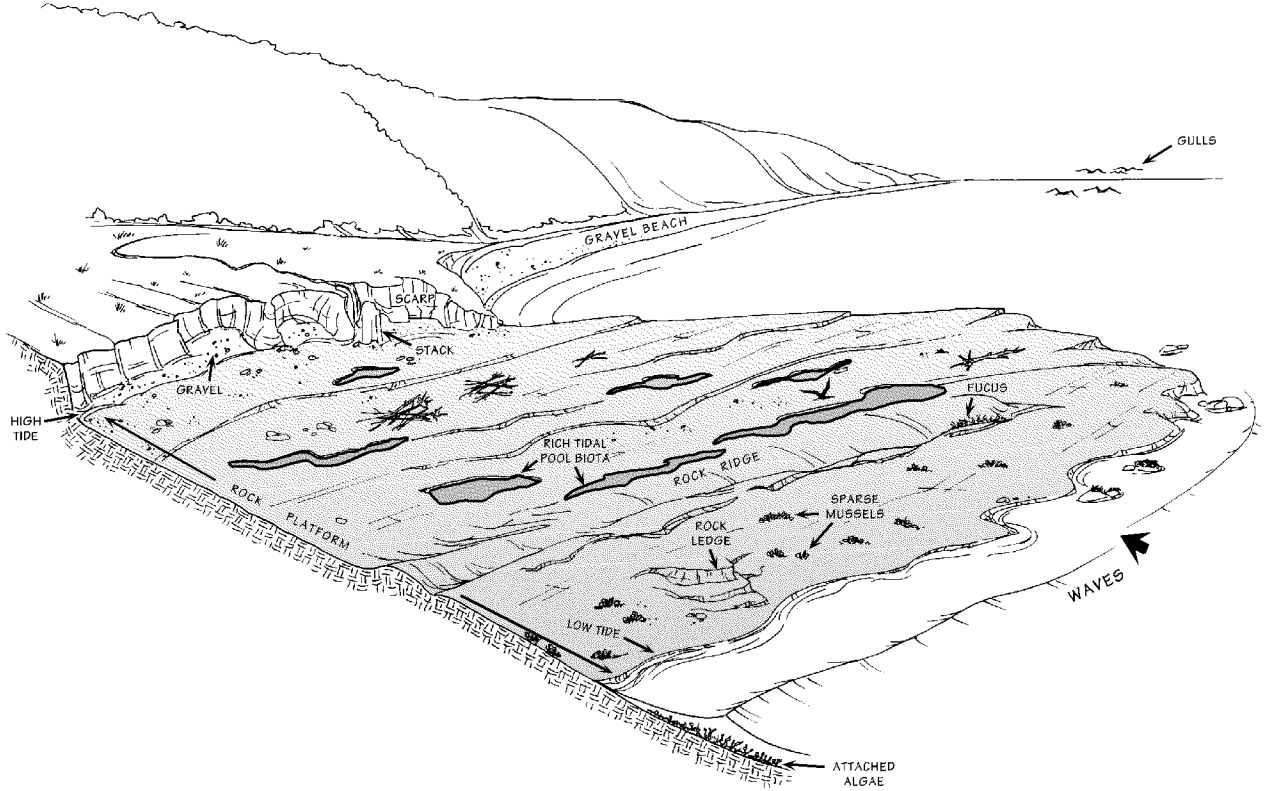
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	A	A	A
Barriers/Berms	–	–	–	–	–
Manual Oil Removal/Cleaning	–	–	B	B	B
Mechanical Oil Removal	–	–	–	–	–
Sorbents	–	B	A	A	A
Vacuum	–	–	–	–	–
Debris Removal	–	–	–	–	–
Sediment Reworking/Tilling	–	–	–	–	–
Vegetation Cutting/Removal	–	–	B	B	B
Flooding (deluge)	–	–	–	–	–
Low-pressure, Ambient Water Flushing	–	A	A	B	B
High-pressure, Ambient Water Flushing	–	B	B	B	B
Low-pressure, Hot Water Flushing	–	–	C	C	C
High-pressure, Hot Water Flushing	–	–	C	C	C
Steam Cleaning	–	–	D	D	D
Sand Blasting	–	–	D	D	D
Solidifiers	–	–	–	–	–
Shoreline Cleaning Agents	–	–	B	B	B
Nutrient Enrichment	–	–	–	–	–
Natural Microbe Seeding	–	–	–	–	–
In-situ Burning	–	–	–	–	–

INTERTIDAL: Exposed, Wave-cut Platforms



Description

- These shores consist of a bedrock shelf or platform of variable width and very gentle slope.
- The surface of the platform is irregular; tide pools are common.
- Along headlands, they have only small accumulation of sediments, mostly at the high-tide line.
- They often co-occur with gravel beaches; the gravel beach can be either at the upper or the lower half of the intertidal zone, depending on the nature of the bedrock outcrop.
- Species density and diversity vary greatly, but barnacles, snails, mussels, and macroalgae are often abundant.

Predicted Oil Behavior

- Oil will not adhere to the wet rock surface, but could penetrate crevices or sediment veneers.
- Oil persistence is usually short-term, except in wave shadows or where the oil was deposited high above normal wave activity.

Response Considerations

- Cleanup is usually not required.
- Where the high-tide area is accessible, it may be feasible to manually remove heavy oil accumulations and oiled debris.

INTERTIDAL: Exposed, Wave-cut Platforms

Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

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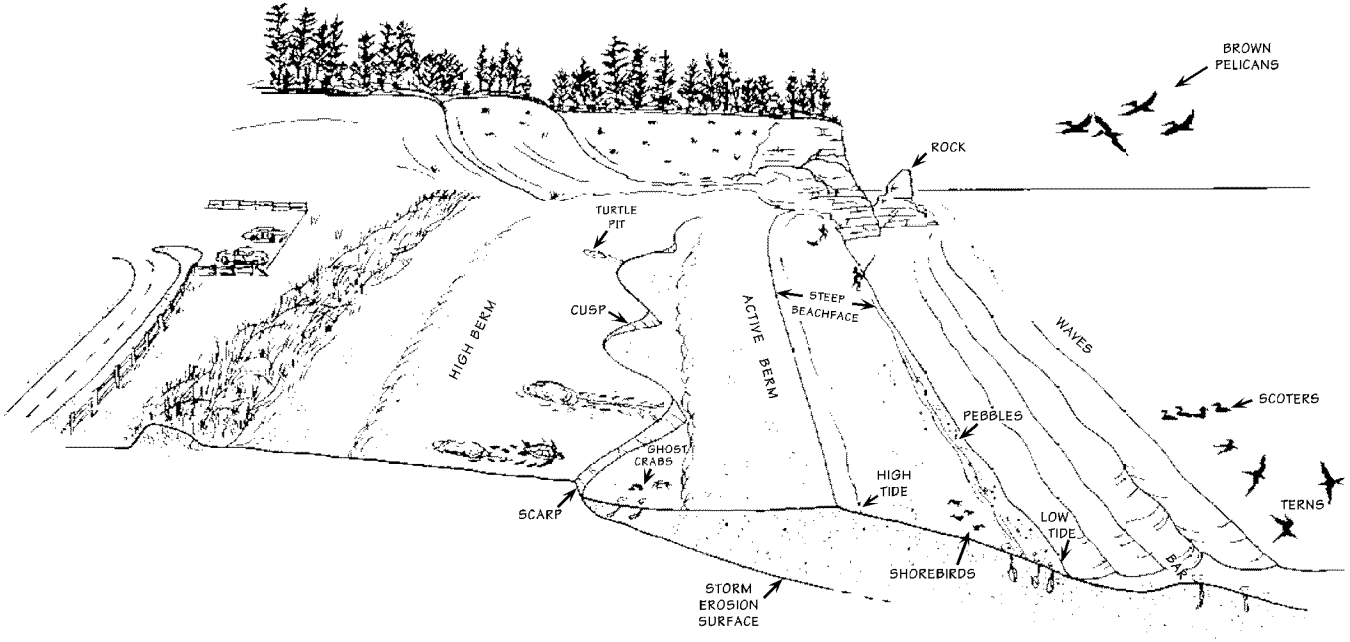
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	A	A	A
Barriers/Berms	–	–	–	–	–
Manual Oil Removal/Cleaning	–	B	B	B	B
Mechanical Oil Removal	–	–	–	–	–
Sorbents	–	B	A	A	A
Vacuum	–	A	A	A	A
Debris Removal	–	A	A	A	A
Sediment Reworking/Tilling	–	–	–	–	–
Vegetation Cutting/Removal	–	–	C	C	C
Flooding (deluge)	–	A	A	B	B
Low-pressure, Ambient Water Flushing	–	A	A	B	B
High-pressure, Ambient Water Flushing	–	B	B	B	B
Low-pressure, Hot Water Flushing	–	D	C	C	C
High-pressure, Hot Water Flushing	–	D	C	C	C
Steam Cleaning	–	–	D	D	D
Sand Blasting	–	–	D	D	D
Solidifiers	–	C	C	–	–
Shoreline Cleaning Agents	–	–	C	C	C
Nutrient Enrichment	–	–	–	–	–
Natural Microbe Seeding	–	I	I	I	I
In-situ Burning	–	D	D	D	–


BROWN PELICANS
ROCK
TURTLE PIT
CUSP
HIGH BERM
ACTIVE BERM
STEEP BEACHFACE
WAVES
SCOTERS
PEBBLES
GHOST CRABS
HIGH TIDE
LOW TIDE
BAR
TERNS
SCARP
SHOREBIRDS
STORM EROSION SURFACE

INTERTIDAL: Sand Beaches

Description

- These beaches are flat to moderately sloping and relatively hard-packed.
- There can be heavy accumulations of wrack.
- They can be important areas for nesting by birds and turtles.
- Upper beach fauna include ghost crabs and amphipods; lower beach fauna can be moderate, but highly variable.

Predicted Oil Behavior

- Light oil accumulations will be deposited as oily swashes or bands along the upper intertidal zone.
- Heavy oil accumulations will cover the entire beach surface; oil will be lifted off the lower beach with the rising tide.
- Maximum penetration of oil into fine- to medium-grained sand is about 10-15 cm, up to 25 cm in coarse-grained sand.
- Burial of oiled layers by clean sand can be rapid (within one day), and burial to depths as much as one meter is possible if the oil comes ashore at the beginning of a depositional period.
- Organisms living in the beach sediment may be killed by smothering or lethal oil concentrations in the interstitial water.
- Biological impacts include temporary declines in infauna, which can affect important shorebird foraging areas.

Response Considerations

- These beaches are among the easiest shoreline types to clean.
- Cleanup should concentrate on removing oil and oily debris from the upper swash zone once most of the oil has come ashore.
- Manual cleanup, rather than road graders and front-end loaders, is advised to minimize volume of sand removed from the shore and requiring disposal.
- All efforts should focus on preventing vehicular and foot traffic from mixing oil deeper into the sediments.
- Mechanical reworking of lightly oiled sediments from the high-tide line to the middle intertidal zone can be effective along exposed beaches.

Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

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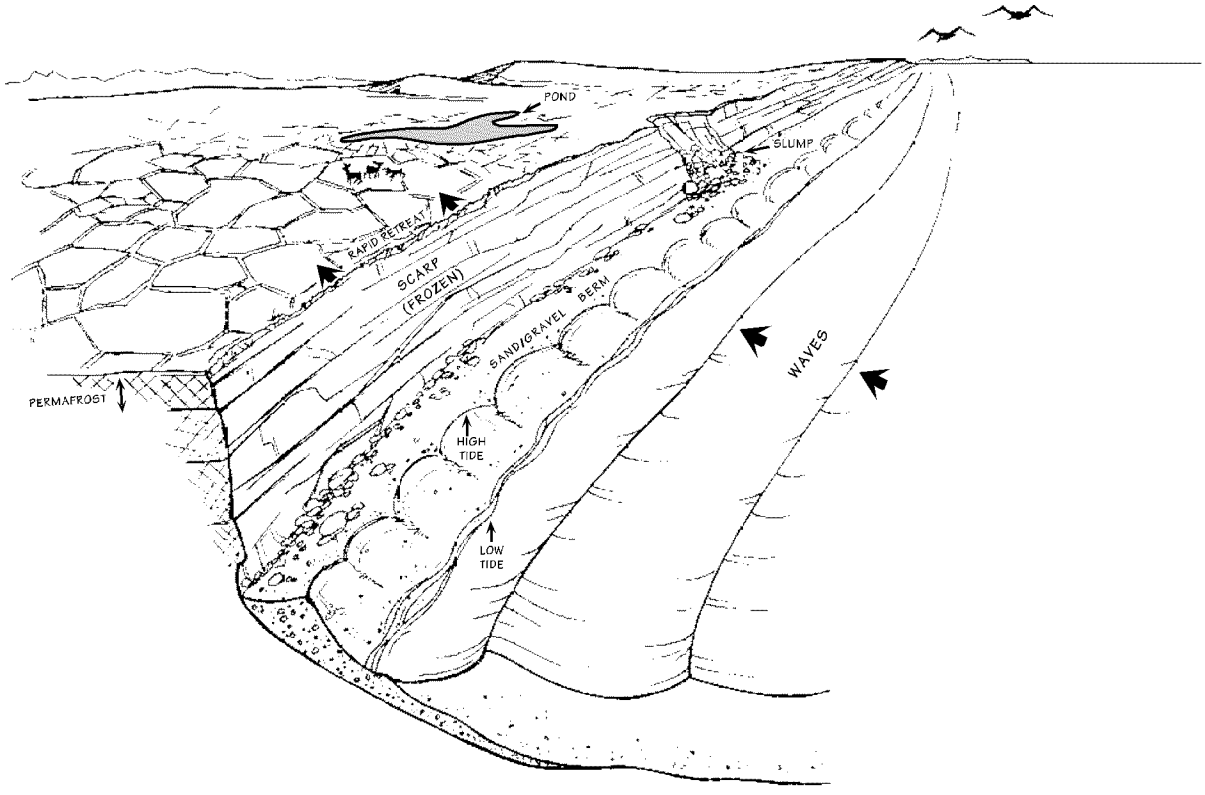
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	B	B	C	C
Barriers/Berms	B	B	B	B	B
Manual Oil Removal/Cleaning	D	B	A	A	A
Mechanical Oil Removal	D	B	B	B	B
Sorbents	–	B	A	A	B
Vacuum	–	–	B	A	A
Debris Removal	–	A	A	A	–
Sediment Reworking/Tilling	D	B	B	B	B
Vegetation Cutting/Removal	–	C	C	C	C
Flooding (deluge)	A	A	A	B	C
Low-pressure, Ambient Water Flushing	B	B	B	B	C
High-pressure, Ambient Water Flushing	–	–	–	–	–
Low-pressure, Hot Water Flushing	–	–	C	C	C
High-pressure, Hot Water Flushing	–	–	–	–	–
Steam Cleaning	–	–	–	–	–
Sand Blasting	–	–	–	–	–
Solidifiers	–	–	B	–	–
Shoreline Cleaning Agents	–	–	C	C	C
Nutrient Enrichment	–	A	A	B	B
Natural Microbe Seeding	–	I	I	I	I
In-situ Burning	–	–	C	C	C

INTERTIDAL: Tundra Cliffs



Description

- These are erosional features with tundra vegetation overlying peat and exposed ground ice or permafrost.
- Cliff heights range from less than 1 meter to as much as 5-10 meters.
- There may be a narrow beach present or just a vertical scarp.
- As the cliffs erode at rates of 0.5-4 meters/year, the vegetation and peat accumulate as fragmented and irregular blocks at the base of the cliff until they are reworked by waves.
- The vegetation on the tundra is a living plant community that is sensitive to disturbances.
- Large numbers of migratory birds can use these shorelines during the summer months.

Predicted Oil Behavior

- Oil could be stranded onshore only during the ice-free summer season.
- Oil is not likely to adhere to exposed ground ice, unless air temperatures are below freezing.
- Oil persistence on the vegetation and peat substrates would be short in most cases, due to natural cliff erosion, provided that the oil is not stranded at the onset of freeze-up.
- If the oil mixes with the peaty substrate or accumulated peat, it could create sheens until the oiled area erodes.
- Biological risks would be greatest to birds feeding along oiled cliffs in summer.

Response Considerations

- Natural peat can be used as a sorbent as long as it is taken from beach peat deposits and not the living tundra.
- Manual or mechanical removal of oil or oiled tundra/peat may be the most practical method if oil removal is required, though the peat substrate is soft and readily trampled.
- Hot-water washing or even low-pressure flushing is not appropriate because they may accelerate thermal and mechanical erosion of the ice in the cliff, triggering unexpected block falls, slumping, or mud flows.
- The cliffs are commonly undercut and naturally unstable, so worker safety is a primary concern.
- Cleanup occurs only in the short arctic summer, a very limited window of intense ecological activity.

INTERTIDAL: Tundra Cliffs

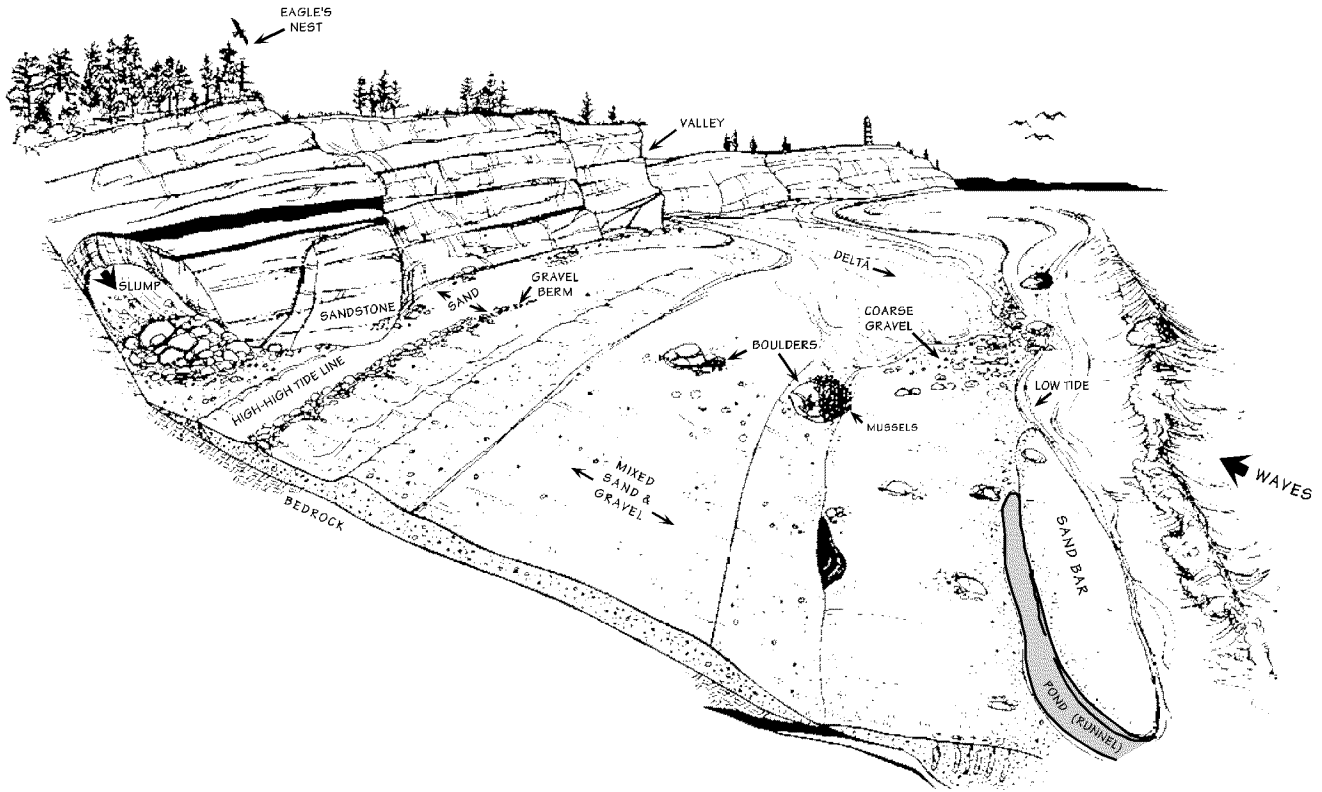
Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

A = The least adverse habitat impact.
B = Some adverse habitat impact.
C = Significant adverse habitat impact.
D = The most adverse habitat impact.
I = Insufficient information - impact or effectiveness of the method could not be evaluated.
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	B	B	B	B
Barriers/Berms	B	B	B	B	B
Manual Oil Removal/Cleaning	D	B	B	B	B
Mechanical Oil Removal	C	C	C	C	C
Sorbents	–	B	A	A	B
Vacuum	–	–	B	A	A
Debris Removal	–	B	B	B	B
Sediment Reworking/Tilling	D	B	B	B	C
Vegetation Cutting/Removal	D	D	D	D	D
Flooding (deluge)	A	A	A	B	C
Low-pressure, Ambient Water Flushing	C	B	B	B	–
High-pressure, Ambient Water Flushing	–	–	–	–	–
Low-pressure, Hot Water Flushing	–	–	–	–	–
High-pressure, Hot Water Flushing	–	–	–	–	–
Steam Cleaning	–	–	–	–	–
Sand Blasting	–	–	–	–	–
Solidifiers	–	–	B	–	–
Shoreline Cleaning Agents	–	–	–	–	–
Nutrient Enrichment	–	B	B	C	C
Natural Microbe Seeding	–	I	I	I	I
In-situ Burning	–	–	–	–	–


EAGLE'S NEST
VALLEY
SLUMP
SANDSTONE
SAND
GRAVEL BERM
DELTA
COARSE GRAVEL
BOULDERS
LOW TIDE
MUSSELS
HIGH-HIGH TIDE LINE
MIXED SAND & GRAVEL
BEDROCK
WAVES
SAND BAR
POND (RUNNEL)

INTERTIDAL: Sand and Gravel Beaches

Description

- Because of the mixed sediment sizes on these moderately sloping beaches, there may be zones of pure sand, pebbles, or cobbles.
- There can be large-scale changes in the sediment distribution patterns depending upon season, because of the transport of the sand fraction offshore during storms.
- Desiccation and sediment mobility on exposed beaches cause low densities of attached animals and plants.
- The presence of attached algae, mussels, and barnacles indicates beaches that are relatively sheltered, with the more stable substrate supporting a richer biota.

Predicted Oil Behavior

- During small spills, oil will be deposited along and above the high-tide swash.
- Large spills will spread across the entire intertidal area.
- Oil penetration into the beach sediments may be up to 50 cm; however, the sand fraction can be quite mobile, and oil behavior is much like on a sand beach if the sand fraction exceeds about 40 percent.
- Burial of oil may be deep at and above the high-tide line, where oil tends to persist, particularly where beaches are only intermittently exposed to waves.
- In sheltered pockets on the beach, pavements of asphalted sediments can form if oil accumulations are not removed, because most of the oil remains on the surface.

Response Considerations

- Remove heavy accumulations of pooled oil from the upper beachface.
- All oiled debris should be removed; sediment removal should be limited as much as possible.
- Low-pressure flushing can be used to float oil away from the sediments for recovery by skimmers or sorbents. High-pressure spraying should be avoided because of potential for transporting contaminated finer sediments (sand) to the lower intertidal or subtidal zones.
- Mechanical reworking of oiled sediments from the high-tide zone to the middle intertidal zone can be effective in areas regularly exposed to wave activity. However, oiled sediments should not be relocated below the mid-tide zone.
- In-place tilling may be used to reach deeply buried oil layers in the mid-tide zone on exposed beaches.

Oil Category Descriptions

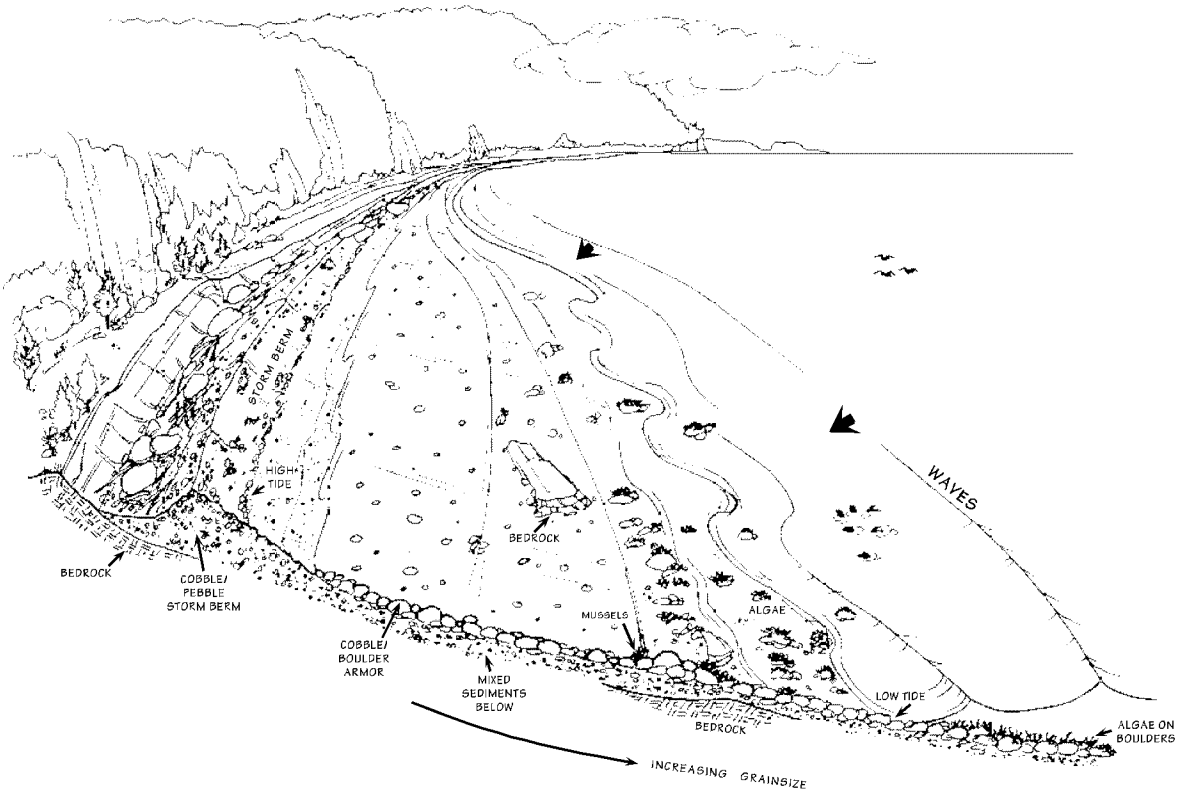
I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

A = The least adverse habitat impact.
B = Some adverse habitat impact.
C = Significant adverse habitat impact.
D = The most adverse habitat impact.
I = Insufficient information - impact or effectiveness of the method could not be evaluated.
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	B	B	C	C
Barriers/Berms	C	C	C	B	B
Manual Oil Removal/Cleaning	D	C	B	B	B
Mechanical Oil Removal	D	C	B	B	B
Sorbents	–	A	A	B	B
Vacuum	–	–	B	B	B
Debris Removal	–	A	A	A	A
Sediment Reworking/Tilling	D	B	B	B	B
Vegetation Cutting/Removal	–	C	C	C	C
Flooding (deluge)	A	A	B	C	C
Low-pressure, Ambient Water Flushing	B	A	A	B	C
High-pressure, Ambient Water Flushing	–	–	C	D	D
Low-pressure, Hot Water Flushing	–	–	C	C	C
High-pressure, Hot Water Flushing	–	–	D	D	D
Steam Cleaning	–	–	D	D	D
Sand Blasting	–	–	–	–	–
Solidifiers	–	–	B	–	–
Shoreline Cleaning Agents	–	–	C	C	C
Nutrient Enrichment	–	A	A	B	C
Natural Microbe Seeding	–	I	I	I	I
In-situ Burning	–	–	C	C	C

INTERTIDAL: Gravel Beaches



Description

- Gravel beaches can be very steep, with multiple wave-built berms forming the upper beach.
- The degree of exposure to wave energy can be highly variable among gravel beaches.
- Density of animals and plants in the upper intertidal zone is low on exposed beaches, but can be high on sheltered gravel beaches and on the lower intertidal zone of all beaches.

Predicted Oil Behavior

- Stranded oil is likely to penetrate deeply into gravel beaches because of their high permeability.
- Rapid burial can occur at the high-tide and storm berms.
- Long-term persistence will be controlled by the depth of routine reworking by the waves.
- On exposed beaches, oil can be pushed over the high-tide berms, pooling and persisting above the normal influence of wave washing.
- Along sheltered portions of the shorelines, chronic sheening and the formation of asphalt pavements is likely where accumulations are heavy.

Response Considerations

- Heavy accumulations of pooled oil should be removed quickly from the upper beach.
- All oiled debris should be removed.
- Sediment removal should be limited as much as possible.
- Low- to high-pressure flushing can be effective if all released oil is recovered with skimmers or sorbents.
- Mechanical reworking of oiled sediments from the high-tide line to the mid beachface can be effective in areas regularly exposed to wave activity; the presence of multiple storm berms is evidence of wave activity. However, oiled sediments should not be relocated below the mid-tide zone.
- In-place tilling may be used to reach deeply buried oil layers along the mid-tide zone on exposed beaches.

INTERTIDAL: Gravel Beaches

Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

A = The least adverse habitat impact.
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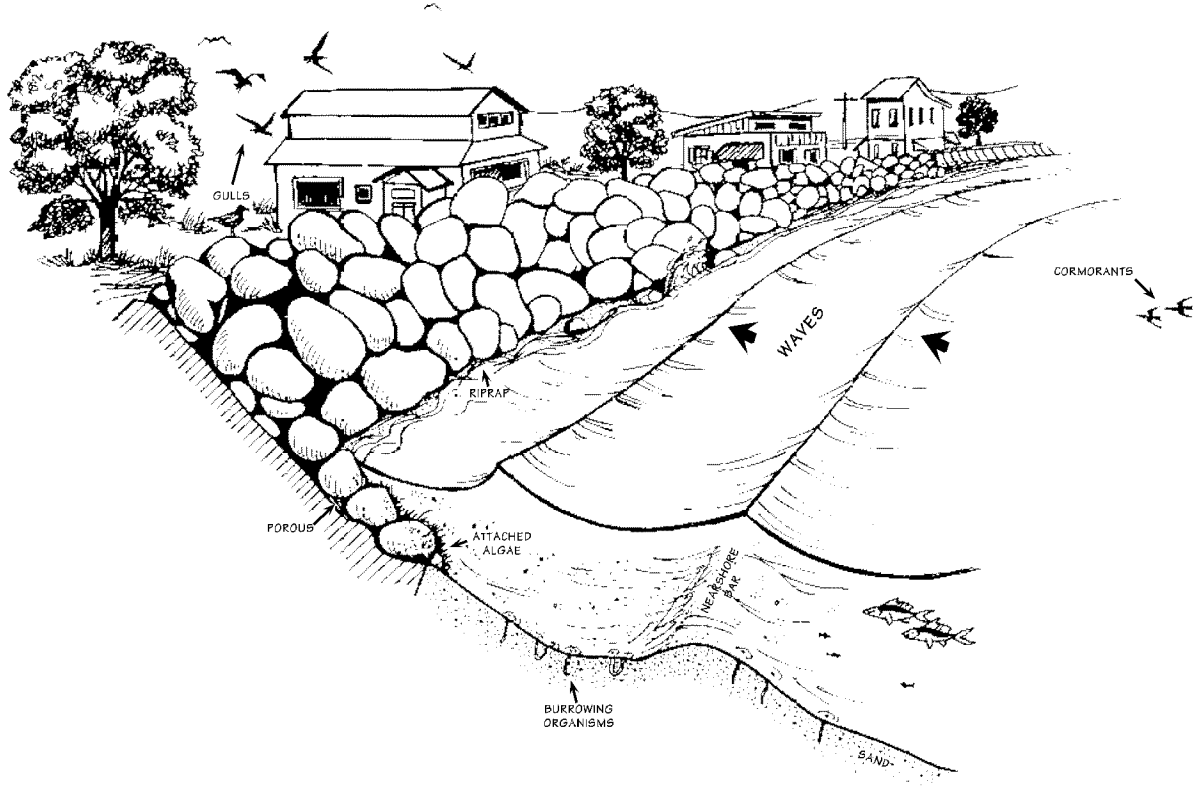
C = Significant adverse habitat impact.
D = The most adverse habitat impact.
I = Insufficient information - impact or effectiveness of the method could not be evaluated.
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	B	B	B
Barriers/Berms	–	B	B	B	B
Manual Oil Removal/Cleaning	D	C	B	B	A
Mechanical Oil Removal	D	D	C	C	C
Sorbents	–	A	A	B	B
Vacuum	–	–	B	B	B
Debris Removal	–	A	A	A	A
Sediment Reworking/Tilling	D	B	B	B	B
Vegetation Cutting/Removal	–	D	C	C	–
Flooding (deluge)	A	A	B	C	C
Low-pressure, Ambient Water Flushing	A	A	A	B	C
High-pressure, Ambient Water Flushing	–	–	B	B	B
Low-pressure, Hot Water Flushing	–	–	C	B	B
High-pressure, Hot Water Flushing	–	–	C	C	C
Steam Cleaning	–	–	D	D	D
Sand Blasting	–	–	–	–	–
Solidifiers	–	–	B	–	–
Shoreline Cleaning Agents	–	–	B	B	B
Nutrient Enrichment	–	A	A	B	B
Natural Microbe Seeding	–	I	I	I	I
In-situ Burning	–	–	C	C	C


GULLS
CORMORANTS
WAVES
RIPRAP
POROUS
ATTACHED ALGAE
NEARSHORE BAR
BURROWING ORGANISMS
SAND

INTERTIDAL: Riprap

Description

- Riprap structures are composed of cobble- to boulder-sized blocks of granite, limestone, concrete, or other materials.
- Riprap structures are used as revetments and groins for shoreline protection, and as breakwaters and jetties around inlets and marinas.
- Attached biota are generally sparse at the upper intertidal zone, but more common in the lower intertidal zone.
- They are common in highly developed waterfront areas.

Predicted Oil Behavior

- Deep penetration of oil between the blocks is likely, with oiling of associated debris.
- Oil adheres readily to the rough surfaces of the blocks.
- Uncleaned oil and debris can cause chronic leaching until the oil hardens.

Response Considerations

- When the oil is fresh and liquid, high pressure spraying and/or water flooding may be effective if all liberated oil is recovered.
- Heavy and weathered oils are more difficult to remove, requiring manual scraping and/or high-pressure, hot-water flushing.
- Removal of oiled debris deep in the crevices will be difficult.

Oil Category Descriptions

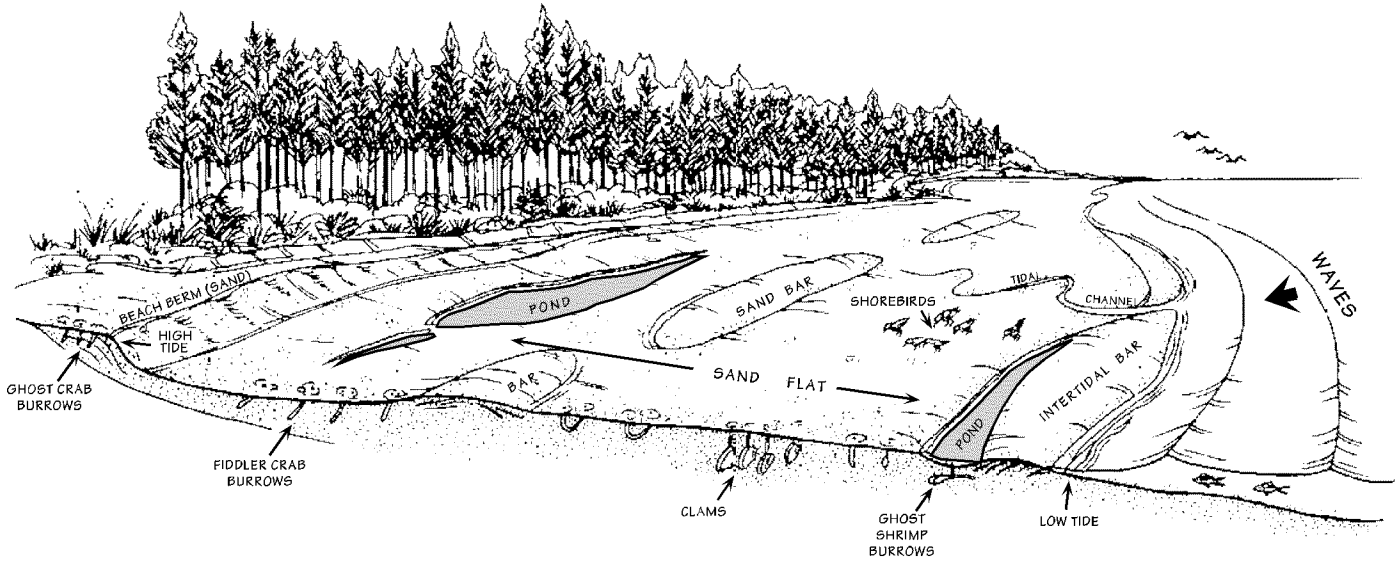
I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

A = The least adverse habitat impact.
B = Some adverse habitat impact.
C = Significant adverse habitat impact.
D = The most adverse habitat impact.
I = Insufficient information - impact or effectiveness of the method could not be evaluated.
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	B	B	B
Barriers/Berms	–	–	–	–	–
Manual Oil Removal/Cleaning	–	A	A	A	A
Mechanical Oil Removal	–	–	C	C	C
Sorbents	–	A	A	B	B
Vacuum	–	–	A	A	A
Debris Removal	–	A	A	A	A
Sediment Reworking/Tilling	–	–	–	–	–
Vegetation Cutting/Removal	–	C	C	B	B
Flooding (deluge)	A	A	B	C	C
Low-pressure, Ambient Water Flushing	A	A	B	C	C
High-pressure, Ambient Water Flushing	A	A	B	B	C
Low-pressure, Hot Water Flushing	–	C	C	C	C
High-pressure, Hot Water Flushing	–	C	C	C	C
Steam Cleaning	–	–	D	D	D
Sand Blasting	–	–	D	D	D
Solidifiers	–	B	B	–	–
Shoreline Cleaning Agents	–	–	B	B	B
Nutrient Enrichment	–	A	A	B	B
Natural Microbe Seeding	–	I	I	I	I
In-situ Burning	–	–	D	D	–

INTERTIDAL: Exposed Tidal Flats



Description

- Exposed tidal flats are broad intertidal areas composed primarily of sand and minor amounts of gravel or mud.
- The presence of sand indicates that tidal currents and waves are strong enough to mobilize the sediments.
- They are usually associated with another shoreline type on the landward side of the flat, though they can occur as separate shoals; they are commonly associated with tidal inlets.
- The sediments are water saturated, with only the topographically higher ridges drying out during low tide.
- Biological use can be very high, with large numbers of infauna, heavy use by birds for roosting and foraging, and use by foraging fish.

Predicted Oil Behavior

- Oil does not usually adhere to the surface of exposed tidal flats, but rather moves across the flat and accumulates at the high-tide line.
- Deposition of oil on the flat may occur on a falling tide if concentrations are heavy.
- Oil does not penetrate water-saturated sediments, but may penetrate coarse-grained sand and coat gravel.
- Biological damage may be severe, primarily to infauna, thereby reducing food sources for birds and other predators.

Response Considerations

- Currents and waves can be very effective in natural removal of the oil.
- Cleanup can be done only during low tide, thus there is a narrow window of opportunity.
- The use of heavy machinery should be restricted to prevent oil mixing into the sediments.
- Manual removal methods are preferred.

INTERTIDAL: Exposed Tidal Flats

Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

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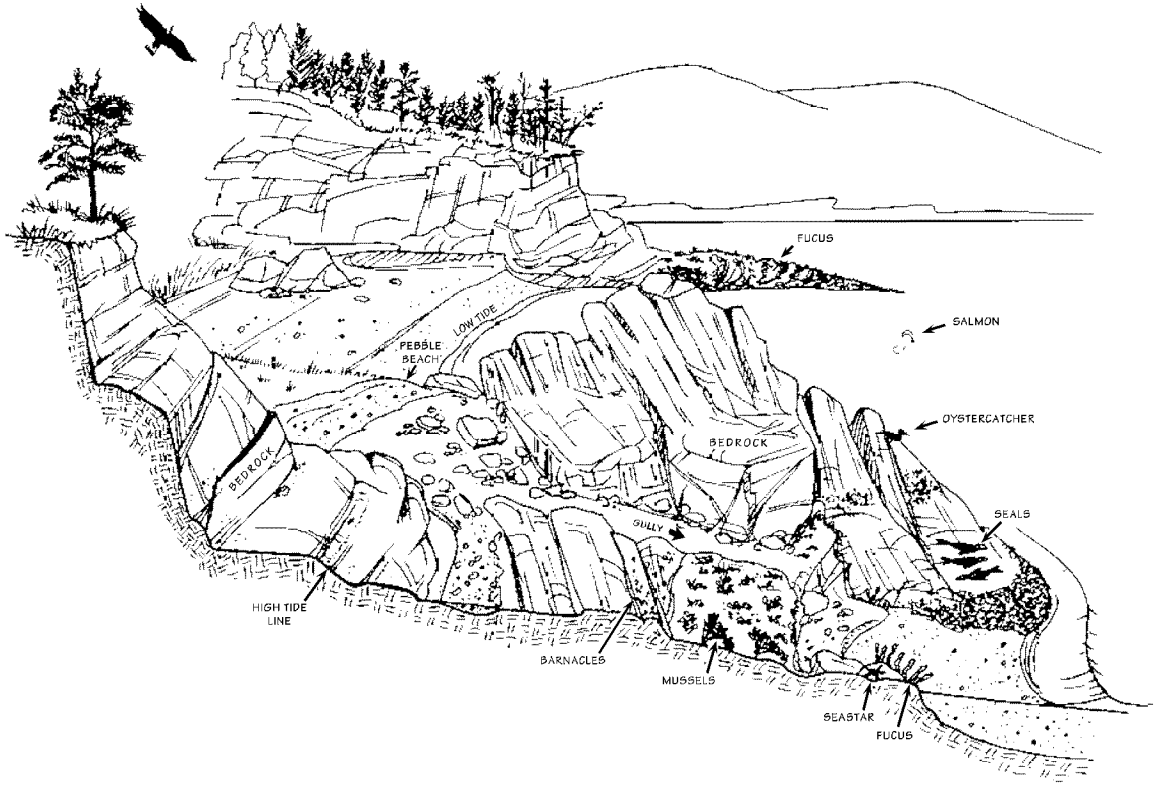
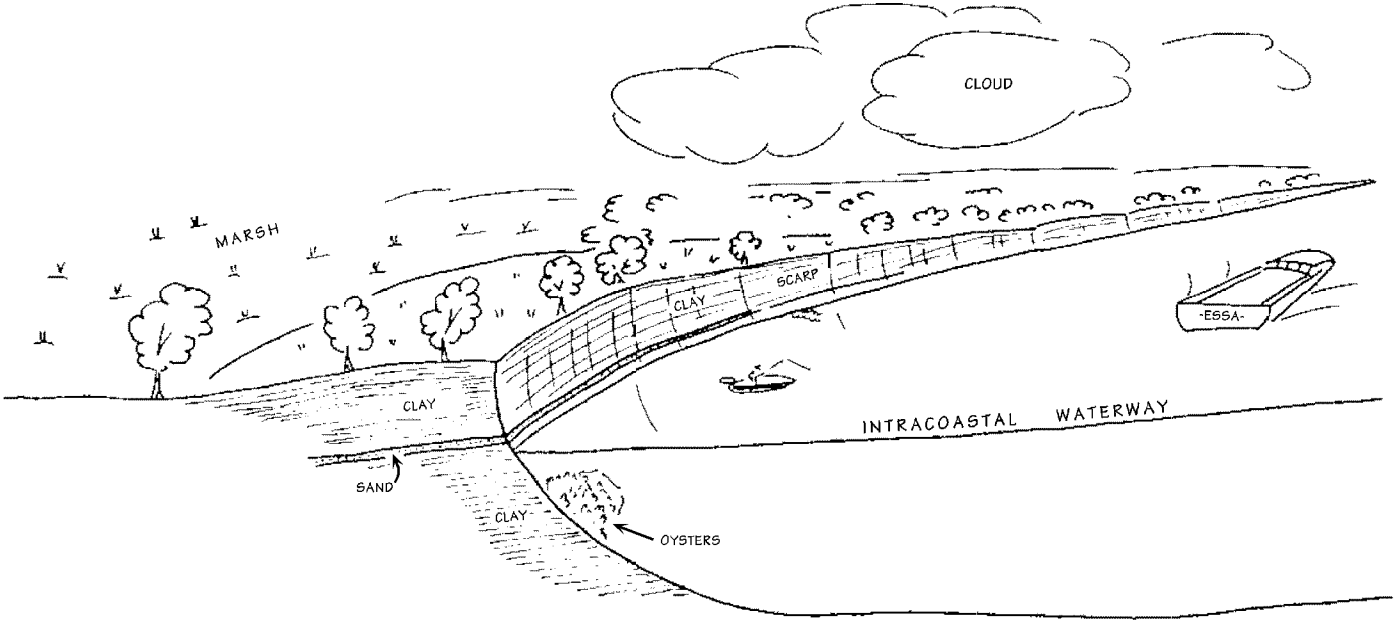
D = The most adverse habitat impact.
I = Insufficient information - impact or effectiveness of the method could not be evaluated.
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	A	A	A
Barriers/Berms	B	B	B	B	B
Manual Oil Removal/Cleaning	–	C	B	B	B
Mechanical Oil Removal	–	D	C	C	C
Sorbents	–	A	A	B	B
Vacuum	–	C	B	B	B
Debris Removal	–	B	B	B	B
Sediment Reworking/Tilling	–	–	C	C	C
Vegetation Cutting/Removal	–	D	D	D	D
Flooding (deluge)	–	A	A	A	B
Low-pressure, Ambient Water Flushing	–	B	B	C	C
High-pressure, Ambient Water Flushing	–	–	–	–	–
Low-pressure, Hot Water Flushing	–	–	–	–	–
High-pressure, Hot Water Flushing	–	–	–	–	–
Steam Cleaning	–	–	–	–	–
Sand Blasting	–	–	–	–	–
Solidifiers	–	C	C	–	–
Shoreline Cleaning Agents	–	–	–	–	–
Nutrient Enrichment	–	C	C	I	I
Natural Microbe Seeding	–	I	I	I	I
In-situ Burning	–	–	–	–	–


FUCUS
SALMON
LOW TIDE
PEBBLE BEACH
OYSTERCATCHER
BEDROCK
BEDROCK
SEALS
GULLY
HIGH TIDE LINE
BARNACLES
MUSSELS
SEASTAR
FUCUS

INTERTIDAL: Sheltered Scarps



Description

- Sheltered rocky shores are characterized by a rocky substrate that can vary widely in permeability. Of particular concern are rocky shores that have a semi-permeable veneer of angular rubble overlying the bedrock.
- Sheltered clay scarps are characterized by a steep, usually vertical scarp in hard-packed and stiff clay. Vegetation usually occurs landward of the scarp.

Predicted oil behavior

- Oil will adhere readily to dry, rough, rocky surfaces, particularly at the high-tide line, forming a distinct oil band.
- The lower intertidal zone of rocky shores is usually algae-covered and stays wet, preventing oil from adhering.
- Oil will not adhere to the wet clay sediment surface, but could penetrate dry sediment.
- Stranded oil will persist because of the low-energy setting.

Response Considerations

- Low-pressure flushing of rocky shores at ambient temperatures is most effective when the oil is fresh and still liquid.
- Extreme care must be taken during flushing operations in the upper intertidal zone to prevent oily effluents from impacting biologically rich lower tidal levels.
- Do not cut oiled, attached algae; use sorbents to recover oil as it is remobilized by tidal action.
- Where the high-water area of scarps is accessible, it might be feasible to manually remove heavy oil accumulations and oiled debris.
- The muddy substrate of scarps cannot support heavy equipment, and even foot traffic could disrupt the sediments and mix oil deeper.

INTERTIDAL: Sheltered Rocky Shores and Scarps

Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

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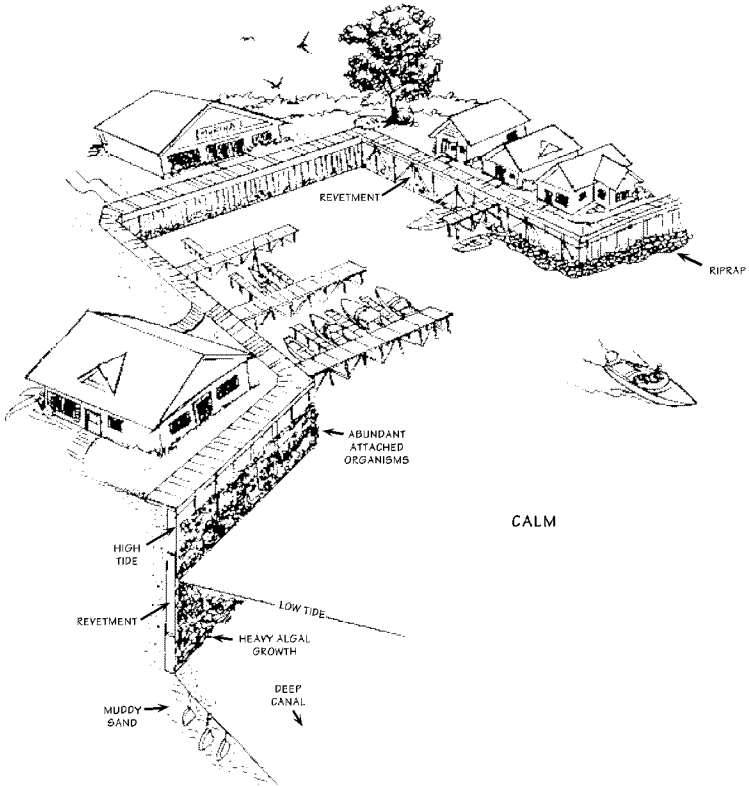
D = The most adverse habitat impact.
I = Insufficient information - impact or effectiveness of the method could not be evaluated.
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	B	B	B
Barriers/Berms	–	–	–	–	–
Manual Oil Removal/Cleaning	–	C	B	C	C
Mechanical Oil Removal	–	–	–	–	–
Sorbents	A	A	B	C	C
Vacuum	–	B	B	B	C
Debris Removal	–	A	A	A	A
Sediment Reworking/Tilling	–	–	–	–	–
Vegetation Cutting/Removal	–	–	D	D	D
Flooding (deluge)	–	A	A	B	C
Low-pressure, Ambient Water Flushing	–	A	A	B	C
High-pressure, Ambient Water Flushing	–	C	B	B	C
Low-pressure, Hot Water Flushing	–	–	D	D	D
High-pressure, Hot Water Flushing	–	–	D	D	D
Steam Cleaning	–	–	D	D	D
Sand Blasting	–	–	D	D	D
Solidifiers	–	C	C	–	–
Shoreline Cleaning Agents	–	–	B	B	B
Nutrient Enrichment	–	A	B	C	C
Natural Microbe Seeding	–	I	I	I	I
In-situ Burning	–	D	C	C	C


REVETMENT
RIPRAP
ABUNDANT ATTACHED ORGANISMS
CALM
HIGH TIDE
LOW TIDE
REVETMENT
HEAVY ALGAL GROWTH
DEEP CANAL
MUDDY SAND

INTERTIDAL: Sheltered, Solid Man-made Structures

Description

- These are structures such as seawalls, groins, revetments, piers, and port facilities, constructed of concrete, wood, or metal.
- Most structures are designed to protect a single lot, thus their composition, design, and condition are highly variable.
- Often there is no exposed beach at low tide, but multiple habitats may be present.
- There can be dense attachments of animal and plant life.
- They are common in developed waterfront areas.

Predicted Oil Behavior

- Oil will adhere readily to the rough surface, particularly along the high-tide line, forming a distinct oil band.
- The lower intertidal zone usually stays wet (particularly if algae-covered), preventing oil from adhering to the surface.

Response Considerations

- Seawalls are usually cleaned for aesthetic reasons or to prevent leaching of oil.
- Low- to high-pressure spraying at ambient water temperatures is most effective when the oil is fresh.

Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

A = The least adverse habitat impact.
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C = Significant adverse habitat impact.
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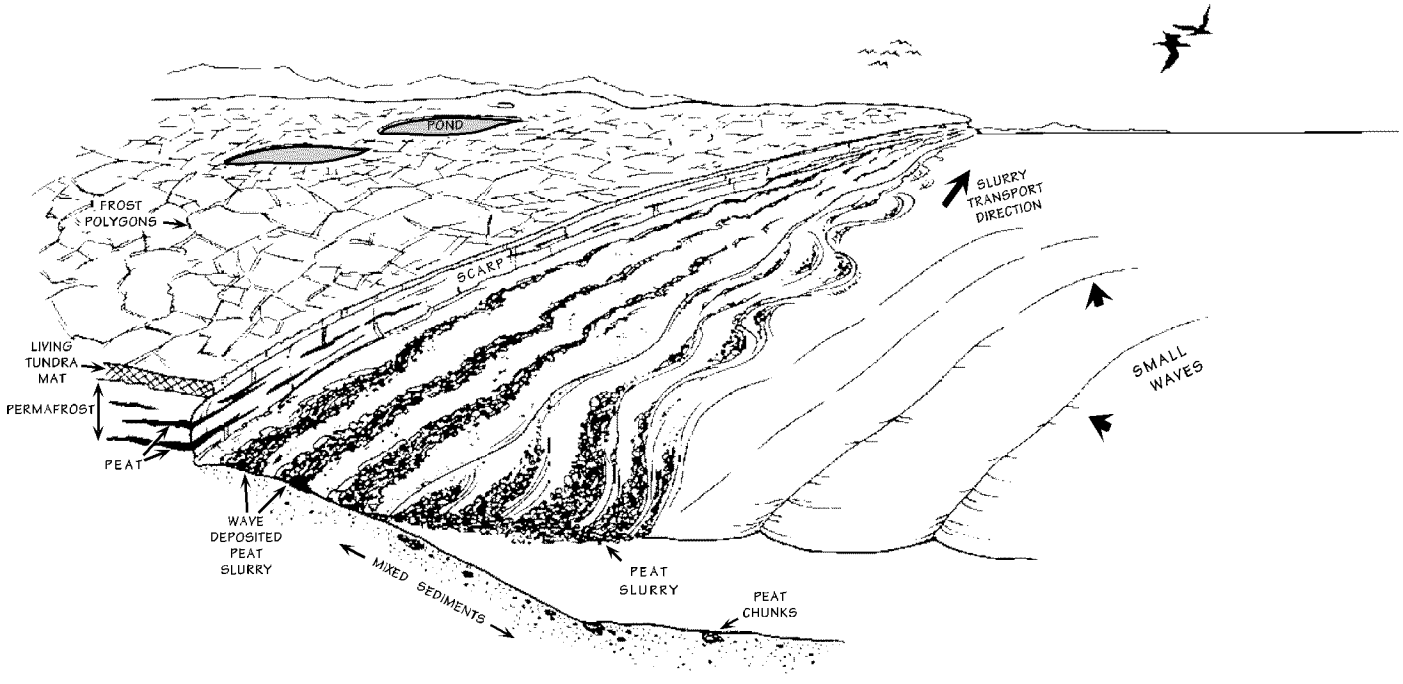
I = Insufficient information - impact or effectiveness of the method could not be evaluated.
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	B	B	B
Barriers/Berms	–	–	–	–	–
Manual Oil Removal/Cleaning	–	B	B	B	B
Mechanical Oil Removal	–	–	–	–	–
Sorbents	–	A	A	B	B
Vacuum	–	–	–	–	–
Debris Removal	–	A	A	A	A
Sediment Reworking/Tilling	–	–	–	–	–
Vegetation Cutting/Removal	–	–	–	–	–
Flooding (deluge)	–	–	–	–	–
Low-pressure, Ambient Water Flushing	–	A	B	C	C
High-pressure, Ambient Water Flushing	–	B	B	C	C
Low-pressure, Hot Water Flushing	–	–	C	C	C
High-pressure, Hot Water Flushing	–	–	C	C	C
Steam Cleaning	–	–	D	D	D
Sand Blasting	–	–	D	D	D
Solidifiers	–	–	–	–	–
Shoreline Cleaning Agents	–	–	B	B	B
Nutrient Enrichment	–	I	I	I	I
Natural Microbe Seeding	–	I	I	I	I
In-situ Burning	–	–	–	–	–


POND
FROST POLYGONS
SCARP
SLURRY TRANSPORT DIRECTION
LIVING TUNDRA MAT
PERMAFROST
PEAT
SMALL WAVES
WAVE DEPOSITED PEAT SLURRY
MIXED SEDIMENTS
PEAT SLURRY
PEAT CHUNKS

Description

- This shoreline type includes exposed peat scarps, eroded peat, and peat slurries.
- Exposed peat scarps occur where the peat is frozen.
- They are highly erosional (>1 meter/year), resulting from wave action, ice scour, and melting of the frozen peat.
- The intertidal zone is often very complex, with slumped peat blocks and a thin (and temporary) sand layer on the peat.
- Eroded peat occurs as a peat mat or veneer in a dewatered state, deposited on a sand or gravel beach; it is usually less than 20 cm thick and considered to be relatively transient.
- Peat slurries (which have the appearance of coffee grounds) are up to 50 cm thick and 10 meters wide.
- Peat slurries are found at the foot of eroding peat scarps and in depositional areas; they are relatively permanent features that move along the shore with the currents.
- Peat shorelines comprise about 70 percent of the Beaufort Sea coast of Alaska.
- The intertidal zone of this shoreline type is not particularly important as biological habitat.

Predicted Oil Behavior

- Oil could be stranded onshore only during the ice-free summer season.
- Oil penetration and persistence are expected to be very low in frozen peat scarps.
- Light oil can penetrate peat slurries, especially when the peat is dry.
- Peat resists penetration by heavy oils, even when dry.
- Peat slurry reacts with oil like loose granular sorbent and will partially contain and prevent the oil from spreading.

Response Considerations

- The peat substrate is soft, thus cleanup will be difficult; trampling is less of concern where peat is frozen or work is conducted from boats.
- Substrate disruption is of limited concern because of high erosion rates so long as adjacent tundra is not disturbed.
- Peat slurry may be used as a natural sorbent; sorption will be more effective with liquid and fresh oils.
- With high erosion rates, stranded oil will have a short residence time.
- Tundra cliffs are commonly undercut and naturally unstable, so safety is a primary concern during response operations.
- Hot-water washing or even low-pressure flushing activities are not appropriate because large quantities of peat could be eroded from the treatment area.

INTERTIDAL: Peat Shores

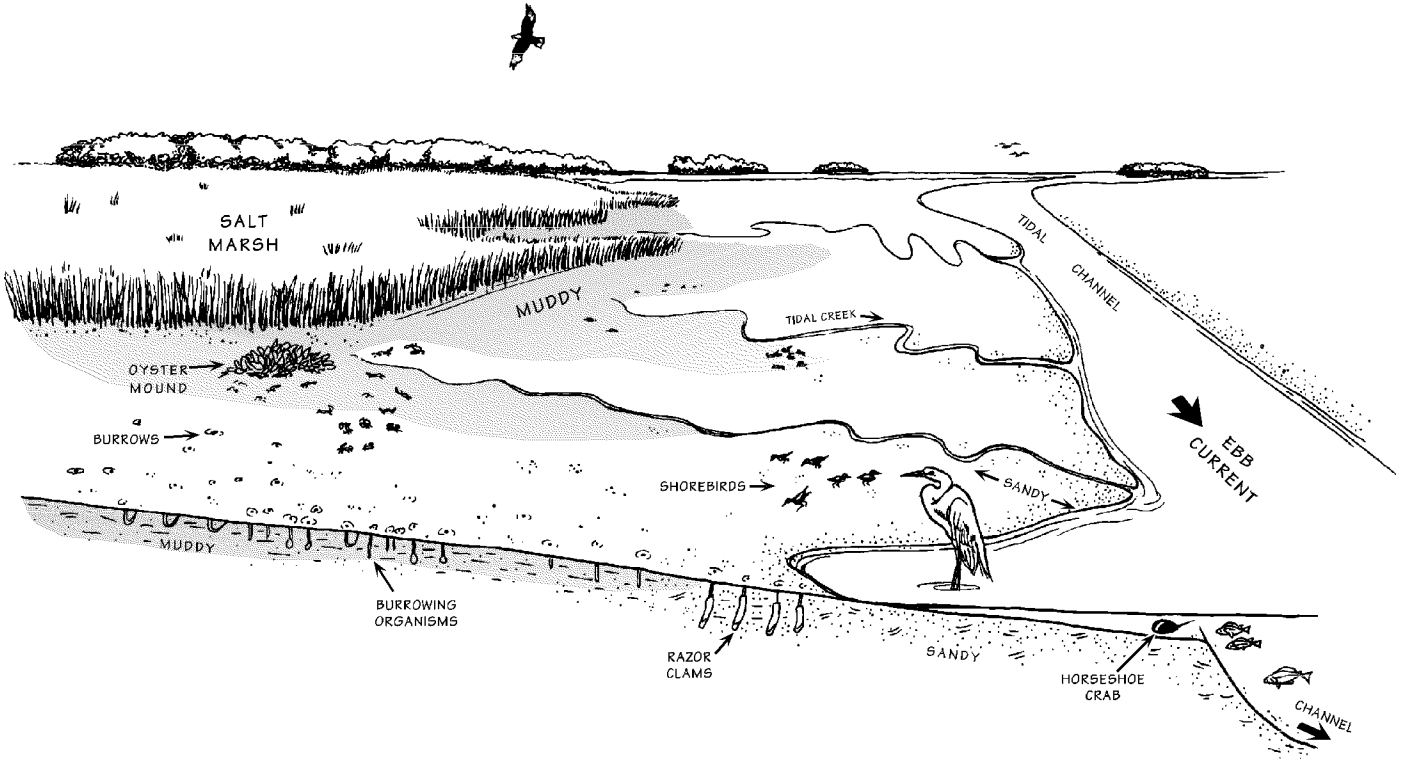
Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

A = The least adverse habitat impact.
B = Some adverse habitat impact.
C = Significant adverse habitat impact.
D = The most adverse habitat impact.
I = Insufficient information - impact or effectiveness of the method could not be evaluated.
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	A	A	A
Barriers/Berms	–	–	–	–	–
Manual Oil Removal/Cleaning	C	B	B	B	B
Mechanical Oil Removal	D	D	D	D	D
Sorbents	–	A	A	B	B
Vacuum	–	B	B	B	B
Debris Removal	C	B	B	B	B
Sediment Reworking/Tilling	C	C	B	B	B
Vegetation Cutting/Removal	D	D	C	C	C
Flooding (deluge)	C	B	B	C	D
Low-pressure, Ambient Water Flushing	C	B	B	C	D
High-pressure, Ambient Water Flushing	–	–	–	–	–
Low-pressure, Hot Water Flushing	–	–	–	–	–
High-pressure, Hot Water Flushing	–	–	–	–	–
Steam Cleaning	–	–	–	–	–
Sand Blasting	–	–	–	–	–
Solidifiers	–	–	–	–	–
Shoreline Cleaning Agents	–	–	–	–	–
Nutrient Enrichment	–	B	B	C	C
Natural Microbe Seeding	–	I	I	I	I
In-situ Burning	–	–	–	–	–


SALT
MARSH
MUDDY
TIDAL CREEK
TIDAL
CHANNEL
OYSTER
MOUND
BURROWS
SHOREBIRDS
SANDY
EBB
CURRENT
MUDDY
BURROWING
ORGANISMS
RAZOR
CLAMS
SANDY
HORSESHOE
CRAB
CHANNEL

INTERTIDAL: Sheltered Tidal Flats

Description

- Sheltered tidal flats are composed primarily of mud with minor amounts of sand and shell.
- They are usually present in calm-water habitats, sheltered from major wave activity, and frequently backed by marshes.
- The sediments are very soft and cannot support even light foot traffic in many areas.
- There can be large concentrations of bivalves, worms, and other invertebrates in the sediments.
- They are heavily used by birds for feeding.

Predicted Oil Behavior

- Oil does not usually adhere to the surface of sheltered tidal flats, but rather moves across the flat and accumulates at the high-tide line.
- Deposition of oil on the flat may occur on a falling tide if concentrations are heavy.
- Oil will not penetrate the water-saturated sediments, but could penetrate burrows and desiccation cracks or other crevices in muddy sediments.
- In areas of high suspended sediment concentrations, the oil and sediments could mix, resulting in the deposition of contaminated sediments on the flats.
- Biological impacts may be severe.

Response Considerations

- These are high-priority areas for protection since cleanup options are limited.
- Cleanup of the flat surface is very difficult because of the soft substrate; many methods may be restricted.
- Low-pressure flushing, vacuum, and deployment of sorbents from shallow-draft boats may be attempted.

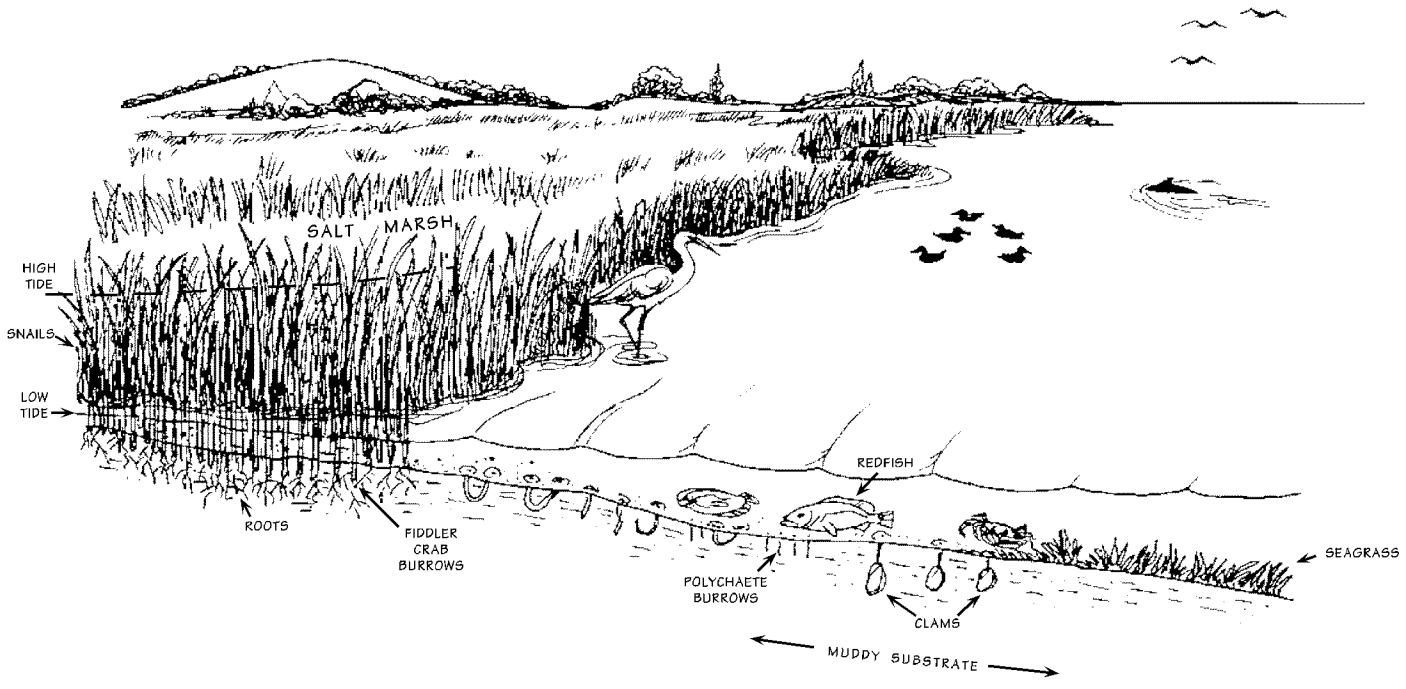
Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

A = The least adverse habitat impact.
B = Some adverse habitat impact.
C = Significant adverse habitat impact.
D = The most adverse habitat impact.
I = Insufficient information - impact or effectiveness of the method could not be evaluated.
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	B	B	B
Barriers/Berms	D	C	C	C	C
Manual Oil Removal/Cleaning	–	D	C	C	–
Mechanical Oil Removal	–	–	–	–	–
Sorbents	–	A	A	B	B
Vacuum	–	C	B	B	B
Debris Removal	–	B	B	B	B
Sediment Reworking/Tilling	–	–	–	–	–
Vegetation Cutting/Removal	–	–	D	D	D
Flooding (deluge)	–	B	B	B	C
Low-pressure, Ambient Water Flushing	–	C	C	D	D
High-pressure, Ambient Water Flushing	–	–	–	–	–
Low-pressure, Hot Water Flushing	–	–	–	–	–
High-pressure, Hot Water Flushing	–	–	–	–	–
Steam Cleaning	–	–	–	–	–
Sand Blasting	–	–	–	–	–
Solidifiers	–	C	C	–	–
Shoreline Cleaning Agents	–	–	–	–	–
Nutrient Enrichment	–	I	I	I	I
Natural Microbe Seeding	–	I	I	I	I
In-situ Burning	–	–	–	–	–


SALT MARSH
HIGH TIDE
SNAILS
LOW TIDE
ROOTS
FIDDLER CRAB BURROWS
REDFISH
POLYCHAETE BURROWS
CLAMS
SEAGRASS
MUDDY SUBSTRATE

Description

- Intertidal wetlands contain emergent, herbaceous vegetation, including both tidal and muted tidal marshes. Depending on location and interannual variations in rainfall and runoff, associated vegetation may include species tolerant or adapted to salt, brackish, or even tidal freshwater conditions.
- The marsh width may vary from a narrow fringe to extensive areas.
- Sediments are composed of organic muds except where sand is abundant on the margins of exposed areas.
- Exposed areas are located along bays with wide fetches and along heavily trafficked waterways.
- Sheltered areas are not exposed to significant wave or boat wake activity.
- Abundant resident flora and fauna with numerous species and high use by birds, fish, and shellfish.

Predicted Oil Behavior

- Oil adheres readily to intertidal vegetation.
- The band of coating will vary widely, depending upon the water level at the time of oiling.
- Large slicks will persist through multiple tidal cycles and will coat the entire stem from the high-tide line to the base.
- Heavy oil coating will be restricted to the outer fringe of thick vegetation, although lighter oils can penetrate deeper, to the limit of tidal influence.
- Medium to heavy oils do not readily adhere to or penetrate the fine sediments, but can pool on the surface or in animal burrows and root cavities.
- Light oils can penetrate the top few centimeters of sediment; under some circumstances oil can penetrate burrows and cracks up to one meter.

Response Considerations

- Under light oiling, the best practice is to let the area recover naturally.
- Natural removal processes and rates should be evaluated before conducting cleanup.
- Heavily pooled oil can be removed by vacuum, sorbents, or low-pressure flushing. During flushing, care must be taken to prevent transporting oil to sensitive areas down slope or along shore.
- Cleanup activities should be carefully supervised to avoid damaging vegetation.
- Any cleanup activity must not mix the oil deeper into the sediments. Trampling of the plants and disturbance of soft sediments must be minimized.
- Aggressive cleanup methods should only be considered when other resources (migratory birds, endangered species) are at greater risk from oiled vegetation left in place.

INTERTIDAL: Salt to Brackish Marshes

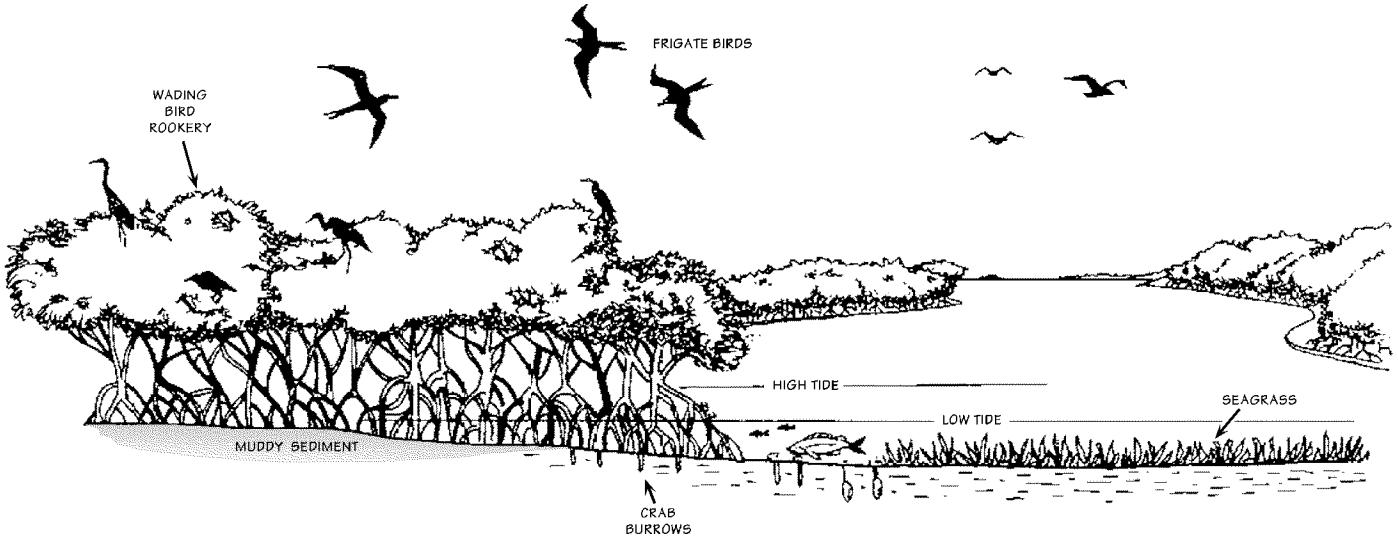
Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

A = The least adverse habitat impact.
B = Some adverse habitat impact.
C = Significant adverse habitat impact.
D = The most adverse habitat impact.
I = Insufficient information - impact or effectiveness of the method could not be evaluated.
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	B	B	B
Barriers/Berms	B	B	B	B	B
Manual Oil Removal/Cleaning	D	D	C	C	C
Mechanical Oil Removal	D	D	D	D	D
Sorbents	–	A	A	A	B
Vacuum	–	B	B	B	B
Debris Removal	–	B	B	B	B
Sediment Reworking/Tilling	D	D	D	D	D
Vegetation Cutting/Removal	D	D	C	C	C
Flooding (deluge)	B	B	B	B	B
Low-pressure, Ambient Water Flushing	B	B	B	B	B
High-pressure, Ambient Water Flushing	–	–	–	–	–
Low-pressure, Hot Water Flushing	–	–	–	–	–
High-pressure, Hot Water Flushing	–	–	–	–	–
Steam Cleaning	–	–	–	–	–
Sand Blasting	–	–	–	–	–
Solidifiers	–	C	C	–	–
Shoreline Cleaning Agents	–	–	B	B	I
Nutrient Enrichment	–	A	B	B	B
Natural Microbe Seeding	–	I	I	I	I
In-situ Burning	–	B	B	B	C


FRIGATE BIRDS
WADING BIRD ROOKERY
HIGH TIDE
LOW TIDE
SEAGRASS
MUDDY SEDIMENT
CRAB BURROWS

INTERTIDAL: Mangroves

Description

- The roots and trunks are intertidal, with only the lowest leaves inundated by high tide.
- The width of the forest can range from one tree, to many kilometers.
- The substrate can be sand, mud, leaf litter, or peat, often as a veneer over bedrock.
- Wrack accumulations can be very heavy.
- They are highly productive, serve as nursery habitat, and support a great diversity and abundance of animal and plant species.

Predicted Oil Behavior

- Oil can wash through mangroves if oil comes ashore at high tide.
- If there is a berm or shoreline present, oil tends to concentrate and penetrate into the berm sediments or accumulated wrack/litter.
- Heavy and emulsified oil can be trapped in thickets of red mangrove prop roots or dense young trees.
- Oil readily adheres to prop roots, tree trunks, and pneumatophores.
- Re-oiling from resuspended or released oil residues may cause additional injury over time.
- Oiled trees start to show evidence of effects (leaf yellowing) weeks after oiling; tree mortality may take months, especially for heavy oils.

Response Considerations

- Oiled wrack can be removed once the threat of oiling has passed. Wrack can actually protect the trees from direct oil contact.
- Sorbent boom can be placed in front of oiled forests to recover oil released naturally.
- In most cases, no other cleanup activities are recommended.
- Where thick oil accumulations are not being naturally removed, low-pressure flushing or vacuum may be attempted at the outer fringe.
- No attempt should be made to clean interior mangroves, except where access to the oil is possible from terrestrial areas.
- It is extremely important to prevent disturbance of the substrate by foot traffic; thus most activities should be conducted from boats.

Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

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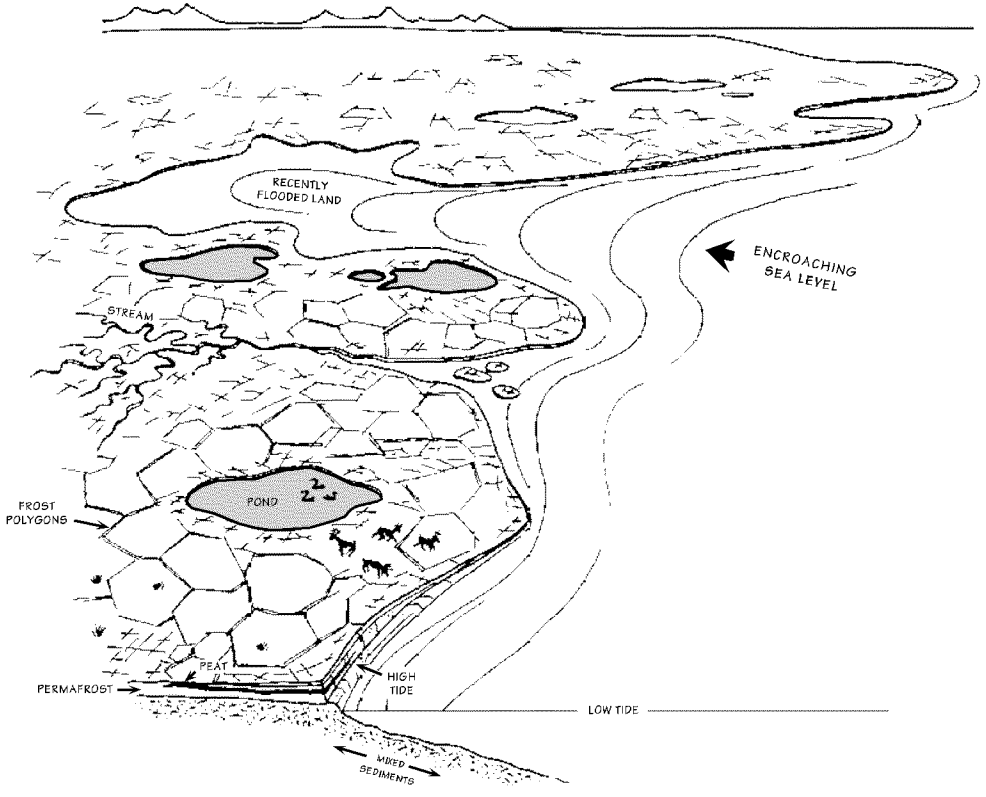
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	A	A	A
Barriers/Berms	B	B	B	B	B
Manual Oil Removal/Cleaning	–	D	C	C	C
Mechanical Oil Removal	–	–	–	–	–
Sorbents	–	A	A	A	B
Vacuum	–	B	B	B	B
Debris Removal	–	A	A	A	A
Sediment Reworking/Tilling	–	–	–	–	–
Vegetation Cutting/Removal	–	–	–	–	–
Flooding (deluge)	–	B	B	B	B
Low-pressure, Ambient Water Flushing	–	B	C	C	C
High-pressure, Ambient Water Flushing	–	–	–	–	–
Low-pressure, Hot Water Flushing	–	–	–	–	–
High-pressure, Hot Water Flushing	–	–	–	–	–
Steam Cleaning	–	–	–	–	–
Sand Blasting	–	–	–	–	–
Solidifiers	–	C	C	–	–
Shoreline Cleaning Agents	–	–	C	C	C
Nutrient Enrichment	–	I	I	I	I
Natural Microbe Seeding	–	I	I	I	I
In-situ Burning	–	–	–	–	–

INTERTIDAL: Inundated Lowland Tundra



Description

- This shoreline type occurs where very low-lying sections of the Arctic shoreline have been recently flooded by the sea, due to subsidence.
- Also includes areas that are not normally in the intertidal zone but can be frequently inundated by salt water during spring tides or wind-induced surges.
- They have complex and convoluted shorelines comprised of tundra, vegetated flats, river banks, peat mats, brackish lagoons, and small streams.
- These shorelines have high ice content; the surface material is mostly peat with little mineral sediments.
- Where present, the vegetation is salt-tolerant and may be more adapted to drier conditions than the salt marshes.
- The tundra is a living plant community and provides important feeding areas for migrating birds in the summer.

Predicted Oil Behavior

- Oil could be stranded onshore only during the ice-free summer season.
- During storm surges, spilled oil could strand hundreds of meters inland.
- During the summer months, the surface sediments/peat deposits are usually water-saturated, so stranded oil is likely to remain on the surface.
- Physical removal rates of medium to heavy oils will be slow.

Response Considerations

- In summer, the substrate will be too soft to support foot or vehicular traffic; any work will require construction of walkways or roads.
- In winter, such work will be less damaging when the load-bearing capacity of these low-lying areas is increased.
- Excessive physical disruption can completely alter the substrate, hydrology, and vegetation patterns for many years.
- Avoid raking and trampling oil into living plants.
- Peat may be used as a natural sorbent; sorption will be more effective with liquid and fresh oils.
- Low-pressure, ambient-water flood and/or flushing could raise the local water table to float and direct oil towards a boomed area for collection.
- If salt-tolerant species are present, seawater may be used; use fresh water only if freshwater species are present.
- Consider burning only where there is an insulating water layer to protect roots and prevent deeper penetration into the substrate. Peat with a high water content may make burning ineffective, leaving a persistent surface residue that is more difficult to remove than the spilled oil.

INTERTIDAL: Inundated Lowland Tundra

Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

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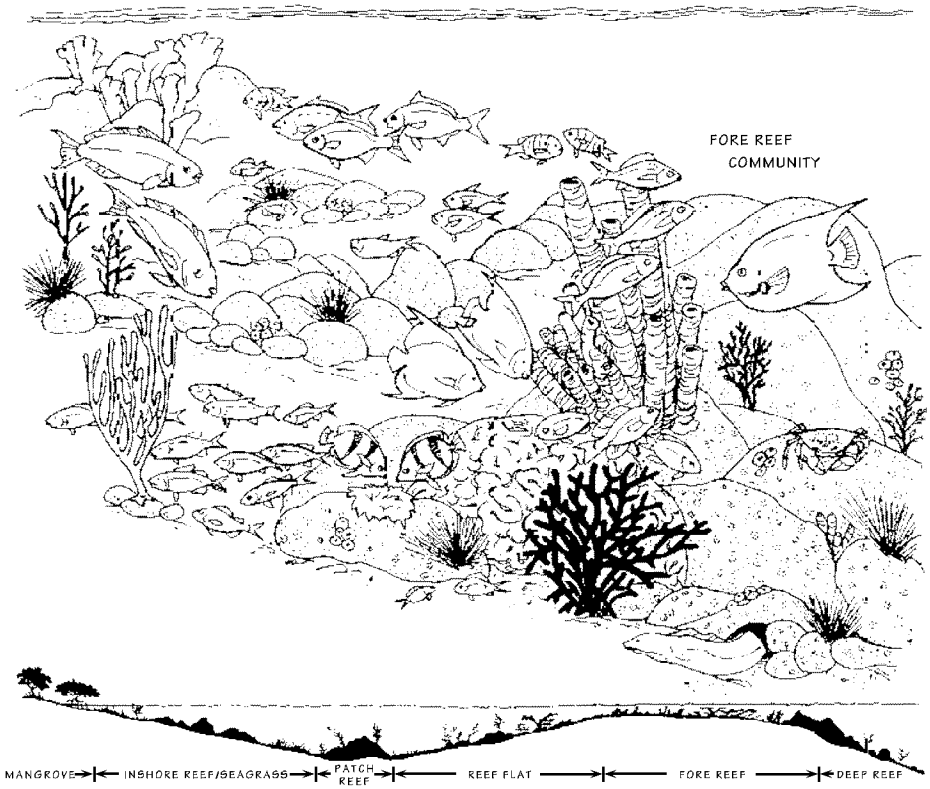
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	A	B	B
Barriers/Berms	–	–	–	–	–
Manual Oil Removal/Cleaning	D	C	C	C	C
Mechanical Oil Removal	D	D	C	C	C
Sorbents	–	C	C	C	–
Vacuum	–	B	B	B	C
Debris Removal	–	C	C	C	C
Sediment Reworking/Tilling	–	–	–	–	–
Vegetation Cutting/Removal	D	D	D	D	D
Flooding (deluge)	C	C	C	D	–
Low-pressure, Ambient Water Flushing	–	D	D	–	–
High-pressure, Ambient Water Flushing	–	–	–	–	–
Low-pressure, Hot Water Flushing	–	–	–	–	–
High-pressure, Hot Water Flushing	–	–	–	–	–
Steam Cleaning	–	–	–	–	–
Sand Blasting	–	–	–	–	–
Solidifiers	–	C	C	–	–
Shoreline Cleaning Agents	–	–	–	–	–
Nutrient Enrichment	–	I	I	I	I
Natural Microbe Seeding	–	I	I	I	I
In-situ Burning	–	C	C	C	–


FORE REEF
COMMUNITY
MANGROVE
INSHORE REEF/SEAGRASS
PATCH REEF
REEF FLAT
FORE REEF
DEEP REEF

SUBTIDAL: Coral Reefs

Description

- Coral reefs are structures created and maintained by the establishment and growth of populations of stony coral and coralline algae.
- Coral reefs are mostly subtidal in nature, although the most shallow portions of some reefs can be exposed during very low tides.
- Broad, pavement-like platforms formed by reefs when they reach sea level are a special concern.
- Many coral species spawn simultaneously over a very short time period (days), a behavior that makes the entire recruitment class very vulnerable.

Predicted Oil Behavior

- Coral reefs vary widely in sensitivity to spilled oil, depending on the water depth, oil type, and duration of exposure.
- There are three primary exposure pathways: direct contact with floating oil; exposure to dissolved and dispersed oil in the water column; and contamination of the substrate by oil deposited on the seafloor.
- Reef-associated community of fishes, crustaceans, sea urchins, etc. can experience significant mortality.

Response Considerations

- Caution is needed when deploying and anchoring booms near reefs to prevent physical damage to the reef.
- Foot and vehicular traffic should not be allowed across a reef flat; access must be from the seaward side via boats.
- The use of dispersants directly over shallow reefs is likely to have significant impacts to the reef community. Their use in offshore areas can reduce impacts to highly sensitive intertidal environments.
- In situ burning outside of the immediate vicinity of reefs can protect sensitive intertidal environments. Burn residues can sink; the potential effects of these residues will depend on the composition and amount of oil.

Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

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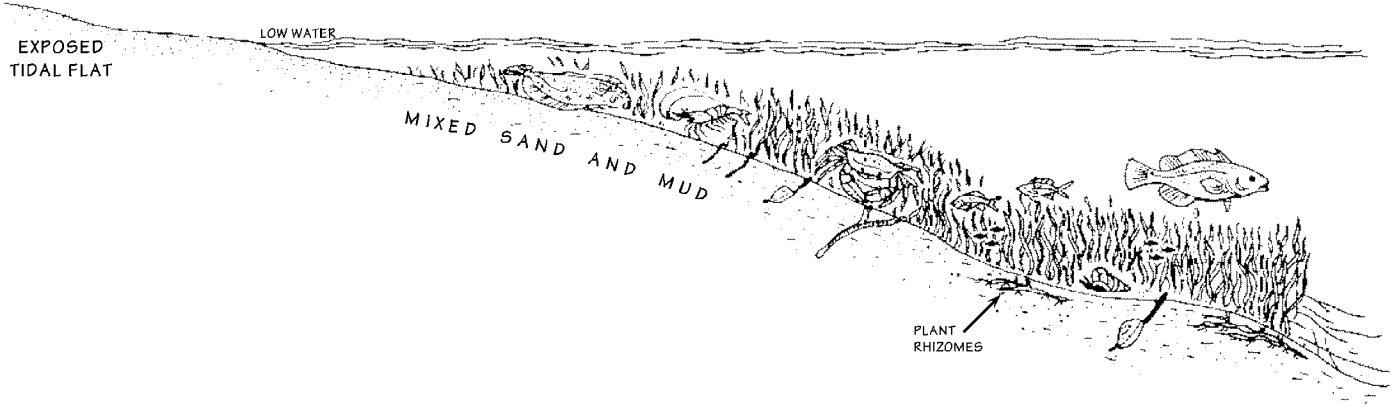
B = Some adverse habitat impact.
C = Significant adverse habitat impact.
D = The most adverse habitat impact.
I = Insufficient information - impact or effectiveness of the method could not be evaluated.
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	A	A	B
Booming	–	B	B	B	–
Skimming	–	B	B	B	–
Physical Herding	–	–	–	–	–
Manual Oil Removal/Cleaning	–	–	B	B	B
Mechanical Oil Removal	–	–	–	D	D
Sorbents	–	A	A	A	B
Vacuum	–	–	B	B	B
Debris Removal	–	–	–	–	–
Vegetation Cutting/Removal	–	–	–	–	–
Low-pressure, Ambient Water	B	B	B	C	C
Dispersants	–	C	C	C	–
In-situ Burning	–	B	C	C	–

SUBTIDAL: Seagrasses



Description

- Seagrasses are highly productive habitats that occur on intertidal flats and in shallow coastal waters worldwide from arctic to tropical climates.
- Water temperature, light penetration, sediment type, salinity, and wave or current energy control seagrass distribution.
- Seagrasses provide a food source for green turtles, manatees, and waterfowl, who graze on seagrasses.
- Seagrasses are used by fish and shellfish as nursery areas.

Predicted Oil Behavior

- Oil will usually pass over subtidal seagrass beds, with no direct contamination.
- Oil that is heavier than seawater can become trapped in the beds, coating the leaves and sediments.
- Oil readily adheres to the vegetation, and the oiled blades are quickly defoliated when intertidal beds are oiled.
- Floating oil stranded on adjacent beaches can pick up sediment and then get eroded and deposited in adjacent beds.

Response Considerations

- Be careful when deploying and anchoring booms to prevent physical damage to seagrass beds.
- Be careful to prevent sediment suspension and mixing with the oil, and disturbance of roots and vegetation by foot traffic and boat activity.
- Do not cut seagrass unless species like sea turtles, manatees, or waterfowl are at significant risk of contacting or ingesting oil.
- Dispersant use directly over subtidal seagrass beds may impact the highly sensitive communities. However, use in offshore areas can reduce impacts to highly sensitive intertidal environments, as well as prevent shoreline stranding in mangroves that can be a chronic source of re-oiling of adjacent seagreass beds.
- In situ burning can be considered outside the immediate vicinity of seagrass beds to protect sensitive intertidal environments. Burn residues can sink; the potential effects of residues will depend on the composition and amount of the oil to be burned.

SUBTIDAL: Seagrasses

Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

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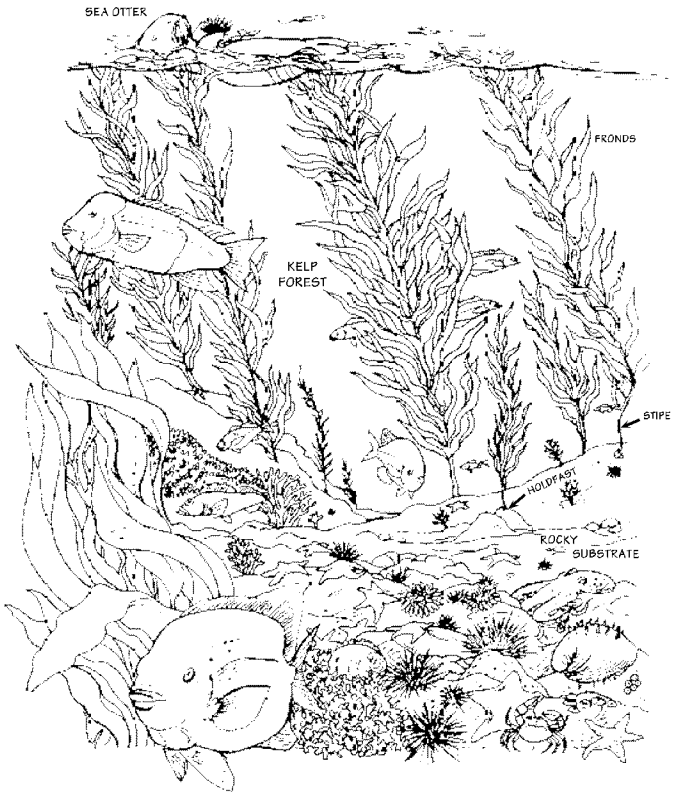
D = The most adverse habitat impact.
I = Insufficient information - impact or effectiveness of the method could not be evaluated.
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	A	B	B
Booming	B	B	B	B	–
Skimming	–	B	B	B	–
Physical Herding	–	B	B	B	–
Manual Oil Removal/Cleaning	–	–	B	B	B
Mechanical Oil Removal	–	–	D	D	D
Sorbents	–	A	A	A	B
Vacuum	–	–	B	B	B
Debris Removal	–	–	B	B	B
Vegetation Cutting/Removal	–	–	C	C	C
Low-pressure, Ambient Water Flushing	–	–	–	–	–
Dispersants	–	C	C	C	–
In-situ Burning	–	B	C	C	–


SEA OTTER
FRONDS
KELP
FOREST
STIPE
HOLDFAST
ROCKY
SUBSTRATE

SUBTIDAL: Kelp

Description

- Kelps are very large brown algae that grow on hard subtidal substrates in cold temperate regions.
- Kelps have a holdfast that attaches to the substrate, a stem-like or trunk-like stipe, and large, flattened, leaf-like blades called fronds.
- Because kelps require constant water motion to provide nutrients, they are located in relatively high-energy settings.
- Kelp forests support a diverse animal community of fish, invertebrates, and marine mammals as well as important algal communities.

Predicted Oil Behavior

- Kelp has a mucous coating that prevents oil from adhering directly to the vegetation on the water surface.
- Oil can be trapped in the dense surface canopy, increasing the persistence of oil within the kelp environment.
- Oil persistence in kelp increases the risks of exposure to organisms concentrated in kelp forest habitats.

Response Considerations

- Cleanup efforts are often hampered by the difficulty of recovering oil from the dense canopy.
- Heavy oils could accumulate in sheltered pockets on the bottom, refloat during storms and re-expose resources to the oil.
- Use caution when anchoring vessels and boom to minimize mechanical damage to the kelp.
- Cutting kelp abruptly changes the light regime to the seafloor below.
- Cutting can be more appropriate for some kelp (*Macrocystis* and *Cystoseria*) than for others (*Nereocystis*).
- The impact of dispersed oil is likely to be greater on the community of organisms associated with the kelp habitat than on the kelp itself.
- In situ burning would be conditional on the absence or removal of mammals and birds in the immediate area. The kelp canopy might act as a natural boom against and within which oil can concentrate to burnable thicknesses.

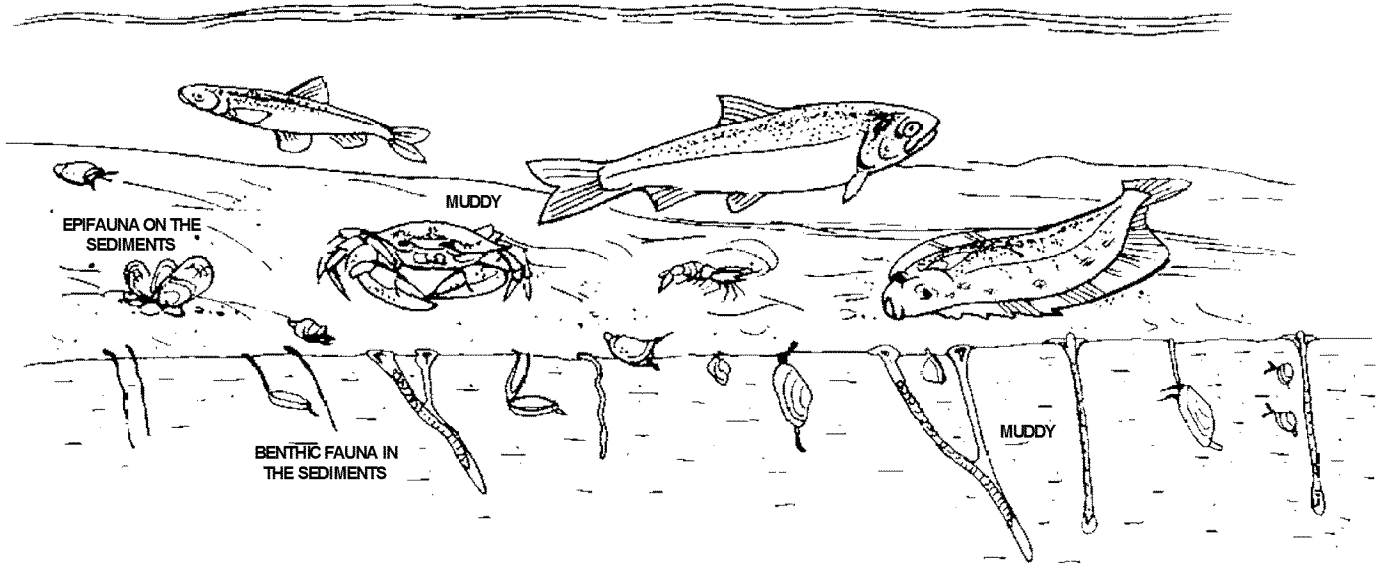
Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

A = The least adverse habitat impact.
B = Some adverse habitat impact.
C = Significant adverse habitat impact.
D = The most adverse habitat impact.
I = Insufficient information - impact or effectiveness of the method could not be evaluated.
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	A	B	B
Booming	–	B	B	B	–
Skimming	–	B	B	B	–
Physical Herding	–	B	B	B	–
Manual Oil Removal/Cleaning	–	–	–	–	–
Mechanical Oil Removal	–	–	–	–	–
Sorbents	–	A	A	A	–
Vacuum	–	B	B	B	–
Debris Removal	–	–	–	–	–
Vegetation Cutting/Removal	–	–	B	B	–
Low-pressure, Ambient Water Flushing	–	–	–	–	–
Dispersants	–	C	C	C	–
In-situ Burning	–	B	C	C	–


MUDDY
EPIFAUNA ON THE SEDIMENTS
BENTHIC FAUNA IN THE SEDIMENTS
MUDDY

Description

- Soft-bottom, subtidal habitats consist of various percentages of sand, silt, and clay, occurring in sheltered bays and estuaries, and deeper offshore areas.
- The presence of fine-grained sediments indicates that the substrate is not exposed to significant wave or tidal energy.
- Biological resources associated with this habitat include shrimp, crabs, clams, fish, and the pelagic and benthic communities that support them (e.g., plankton, worms, amphipods, isopods).

Predicted Oil Behavior

- This habitat is not often exposed to spilled oil. The greatest risk of exposure is from the sinking oil or the sorption of dispersed oil onto suspended sediments that are then deposited on the bottom.
- Significant natural dispersion of oil and sediments into the water column occurs only during large storms and nearshore oil spills.
- Shoreline cleanup can suspend oil and fine-grained sediments, causing deposition of oily sediments in nearshore habitats.
- Concerns about seafood contamination from dispersed oil or oiled sediments can become a significant issue. Real, potential, or fear of contamination can close seafood harvesting activities.

Response Considerations

- Removal might be needed where significant amounts of oil have sunk and formed mats or concentrations of tarballs on the sediment surface.
- Special efforts will be needed to control suspended sediments and resuspended oil during recovery operations.
- Dispersants can be used over soft subtidal habitats in order to protect more sensitive intertidal environments. Effects on biota are less for applications in deep water or high dilution rates.
- In situ burning can be used to protect sensitive intertidal environments. When burned, some oils can produce a sinkable residue; the potential effects of these residues will depend on the composition and amount of oil to be burned.

SUBTIDAL: Soft Bottom

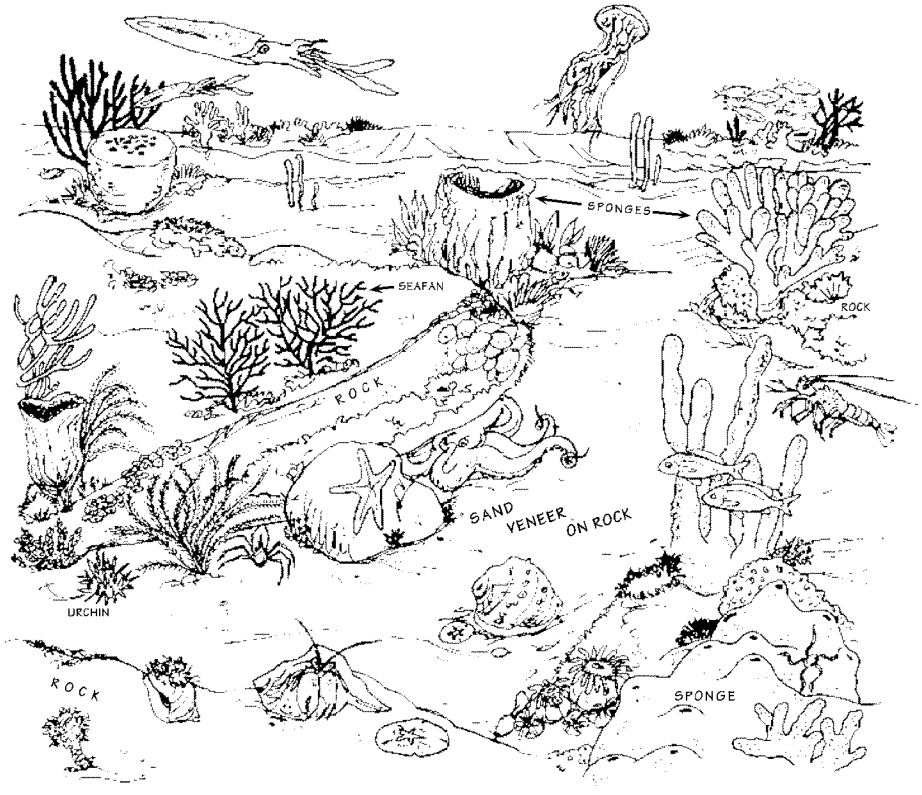
Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

A = The least adverse habitat impact.
B = Some adverse habitat impact.
C = Significant adverse habitat impact.
D = The most adverse habitat impact.
I = Insufficient information - impact or effectiveness of the method could not be evaluated.
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	A	B	B
Booming	A	A	A	A	–
Skimming	–	A	A	A	–
Physical Herding	–	B	B	B	–
Manual Oil Removal/Cleaning	–	–	B	B	B
Mechanical Oil Removal	–	–	–	C	C
Sorbents	–	A	A	A	B
Vacuum	–	–	B	B	B
Debris Removal	–	–	–	–	–
Vegetation Cutting/Removal	–	–	–	–	–
Low-pressure, Ambient Water Flushing	–	–	–	–	–
Dispersants	–	C	C	C	–
In-situ Burning	–	B	B	B	–


SPONGES
SEAFAN
ROCK
ROCK
SAND
VENEER
ON ROCK
URCHIN
ROCK
SPONGE

SUBTIDAL: Mixed and Hard Bottom

Description

- This habitat consists of subtidal substrates composed of rock, boulders, or cobbles, though there can be patches of sand veneer covering a hard bottom.
- There may be rich, diverse communities of attached and associated algae and animals; often there is little open space.
- Some of these habitats form a relief (reef or bank) several meters high that attracts a diversity of fish.

Predicted Oil Behavior

- Mixed and hard-bottom habitats are usually considered to have low risk of exposure to oil spills.
- Oil in the water column seldom reaches toxic levels and benthic organisms have little exposure.
- There is little risk of deposition of oil or oiled sediments in these habitats.
- There could be a short-term exposure as oiled sediments are transported through the habitat into deeper areas.
- Concerns about seafood contamination from dispersed oil or oiled sediments can become a significant issue. Real, potential, or fear of contamination can close seafood harvesting activities.

Response Considerations

- Natural cleansing is expected to occur quickly, especially in the higher-energy environments.
- Avoid anchoring booms in known sensitive areas, such as unique live-bottom areas.
- Dispersants can be used directly over these habitats to protect sensitive intertidal areas. The deeper the water, the greater the dilution, and hence the lesser effect it will have on the mixed and hard-bottom habitats.
- In situ burning can be used directly over these habitats to protect sensitive intertidal environments. When burned, some oils can produce a sinkable residue; the potential effects of these residues will depend on the composition and amount of oil to be burned.

Oil Category Descriptions

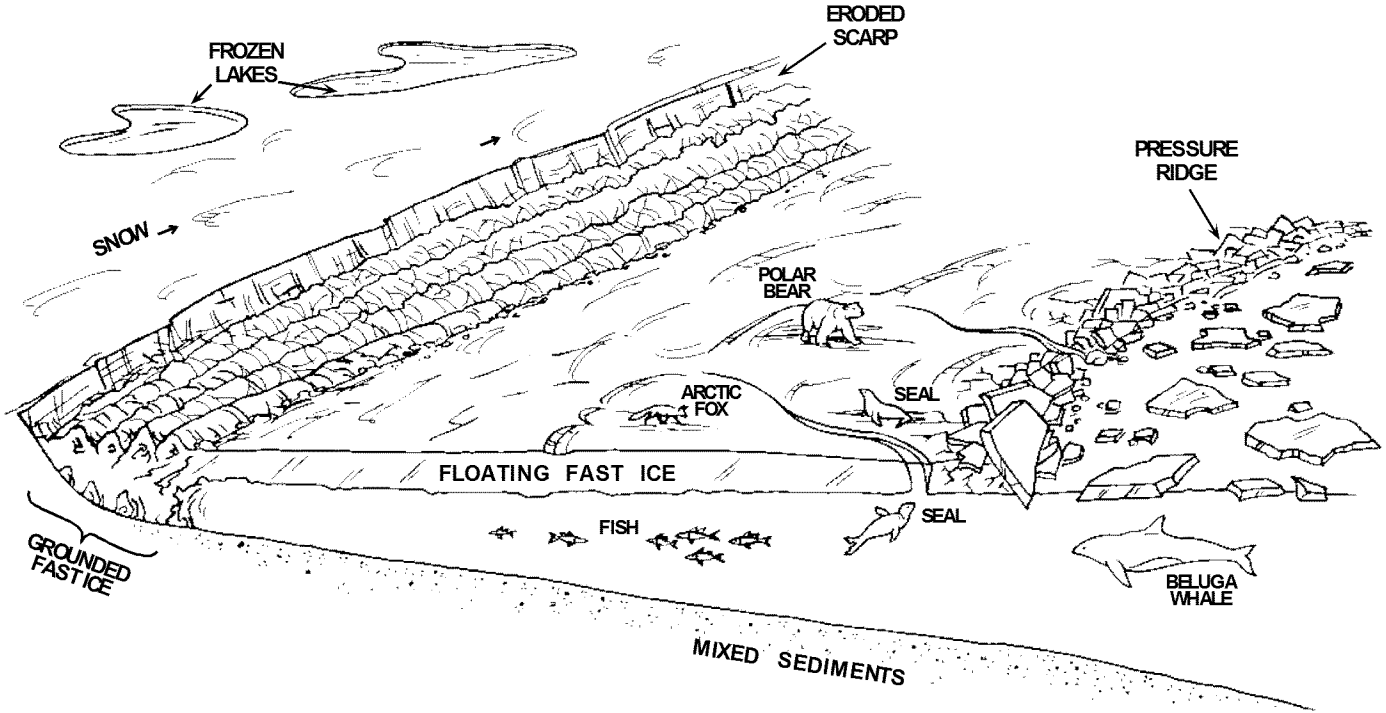
I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

A = The least adverse habitat impact.
B = Some adverse habitat impact.
C = Significant adverse habitat impact.
D = The most adverse habitat impact.
I = Insufficient information - impact or effectiveness of the method could not be evaluated.
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	A	B	B
Booming	–	B	B	B	–
Skimming	–	A	A	A	–
Physical Herding	–	A	A	A	–
Manual Oil Removal/Cleaning	–	–	B	B	B
Mechanical Oil Removal	–	–	–	–	–
Sorbents	–	A	A	A	B
Vacuum	–	–	B	B	B
Debris Removal	–	B	B	B	B
Vegetation Cutting/Removal	–	–	–	–	–
Low-pressure, Ambient Water Flushing	–	–	–	–	–
Dispersants	–	B	B	B	–
In-situ Burning	–	B	B	B	–

ICE: Accessible and Inaccessible Ice



Description

- Ice forms on the sea surface during winter in cold climates and can persist for several months.
- Most sea surface ice is floating but can be frozen to the bottom or stranded in intertidal areas during low tide.
- Accessible ice can safely support the personnel and equipment suitable for response to a particular oil spill on, in, under, or adjacent to solid ice.
- Inaccessible ice cannot safely support response personnel and response equipment.

Predicted Oil Behavior

- Ice along the shoreline or in the adjacent nearshore water can act as a natural barrier, reducing the amount of oil that might otherwise make contact with the shoreline substrate.
- During the ice growth phase, oil in or under the ice can become encapsulated within the ice.
- During a thaw, or if the surface of the ice is melting and wet, oil is unlikely to adhere to the ice surface and will tend to remain on the water surface or in leads.

  In the spring, before the ice becomes inaccessible, oil in or below sea ice will often migrate through brine channels to the surface.

Response Considerations

- The ice habitat presents unique safety issues in terms of cold, ice stability, and wildlife interactions.
- Oil spills on, in, under, or adjacent to brash ice, small or fast moving floes, or other ice types which are “inaccessible” must be treated from the air or from vessels working in, or alongside, the ice.
- Some methods, including flooding, debris removal, sediment reworking, vegetation cutting and removal, high-pressure flushing, sand blasting, solidifiers, and shoreline cleaning agents, are not considered suitable for use in these environments.

ICE: Accessible Ice

Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

A = The least adverse habitat impact.
B = Some adverse habitat impact.
C = Significant adverse habitat impact.
D = The most adverse habitat impact.
I = Insufficient information - impact or effectiveness of the method could not be evaluated.
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	B	B	C	C
Booming	–	B	B	B	–
Skimming	–	A	A	A	–
Barriers/Berms	B	B	B	–	–
Physical Herding	B	B	B	B	–
Manual Oil Removal/Cleaning	–	A	A	A	A
Mechanical Oil Removal	–	B	B	B	B
Sorbents	–	B	B	B	–
Vacuum	–	A	A	A	A
Low-pressure, Ambient Water Flushing	B	B	B	B	C
Low-pressure, Hot Water Flushing	–	B	B	B	C
Steam Cleaning	–	B	B	B	–
Dispersants	–	B	B	–	–
Emulsion-treating Agents	–	I	I	I	I
Elasticity Modifiers	–	A	–	–	–
Herding Agents	I	I	I	–	–
Nutrient Enrichment	–	I	I	I	I
Natural Microbe Seeding	–	I	I	I	I
In-situ Burning	B	B	B	B	–

Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. This method may cause:

A = The least adverse habitat impact.
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D = The most adverse habitat impact.
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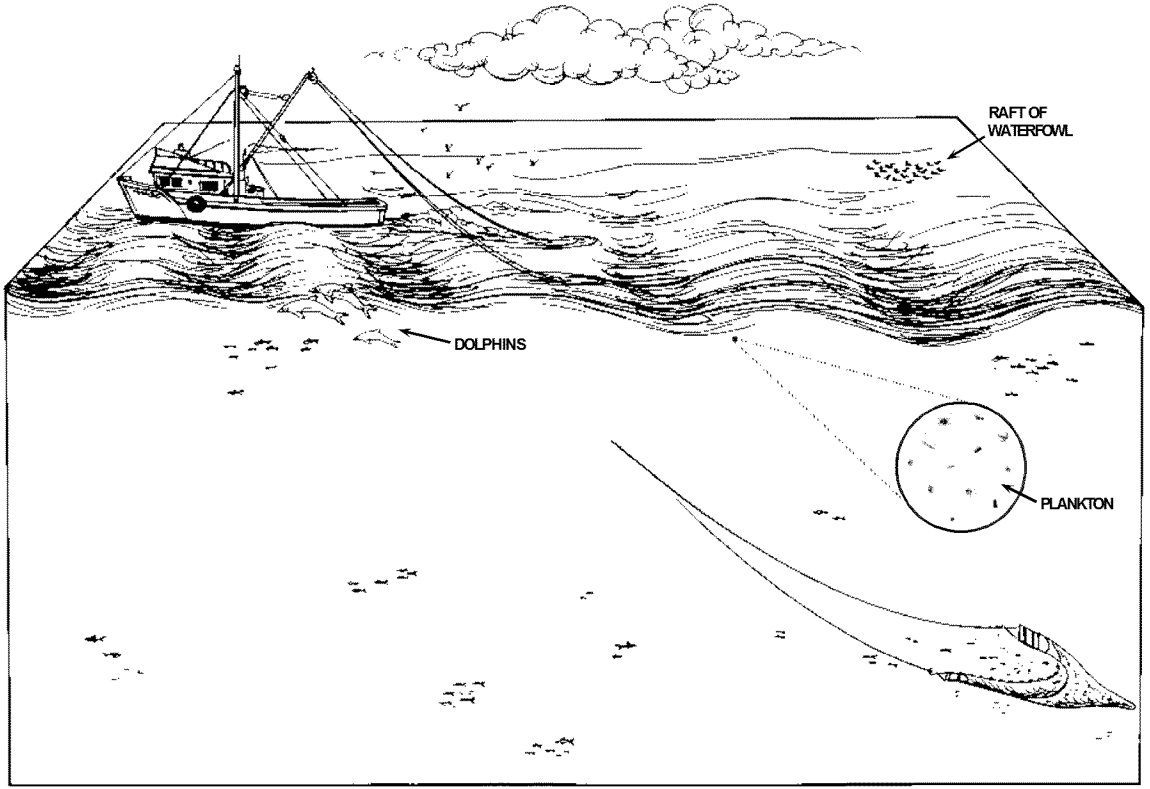
– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	B	B	B
Booming	–	B	B	B	–
Skimming	–	A	A	A	–
Barriers/Berms	–	–	–	–	–
Physical Herding	–	–	–	–	–
Manual Oil Removal/Cleaning	–	–	–	–	–
Mechanical Oil Removal	–	–	–	–	–
Sorbents	–	–	–	–	–
Vacuum	–	–	–	–	–
Low-pressure, Ambient Water Flushing	–	–	–	–	–
Low-pressure, Hot Water Flushing	–	–	–	–	–
Steam Cleaning	–	–	–	–	–
Dispersants	–	B	B	–	–
Emulsion-treating Agents	–	I	I	I	I
Elasticity Modifiers	–	–	–	–	–
Herding Agents	I	I	I	–	–
Nutrient Enrichment	–	I	I	I	I
Natural Microbe Seeding	–	I	I	I	I
In-situ Burning	B	B	B	–	–


RAFT OF
WATERFOWL
DOLPHINS
PLANKTON

Description

- Offshore waters are those where the water depth is > 30 feet (10 meters) with no surrounding land.
- Evaluation of environmental impacts to open water habitats is focused on water column organisms and those which inhabit or use the sea surface.
- Animals include marine mammals, sea turtles, pelagic birds, and many commercially and recreationally important fish and pelagic invertebrates.
- Organism densities in this habitat are low on average.
- Localized high densities can occur in areas such as convergence zones and upwelling areas.
- Pelagic birds are at greatest risk when large numbers are concentrated for feeding, migration, overwintering, or breeding.
- Biological resources in the water column are less vulnerable to spills than those at the water surface.
- The sea surface microlayer is important for biochemical processes; the organisms most vulnerable to exposure are poor or passive swimmers (planktonic forms).

Predicted Oil Behavior

- Spilled oil transport is controlled more by wind and ocean currents than by tides and mixing with freshwater outflows.
- Most of the soluble and toxic components of the spilled oil are lost through weathering within hours and days.
- Dissolved or dispersed oil concentrations are likely to be greatest in the top few meters.

Response Considerations

- Response activities are focused on removing oil from the water surface.
- Spill response is not conducted from a shoreline, but from water-based vessels or aircraft.
- Weather and sea conditions can significantly hamper response operations.
- Category V oils are likely to submerge and most of the response methods can only be used on the surface of the water.
- Special equipment might be needed for some products (e.g., containment booms which extend at least 9 ft.).

Use of certain response options is seasonally limited to protect sensitive life histories.

Oil Category Descriptions

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V – Non-floating oil products

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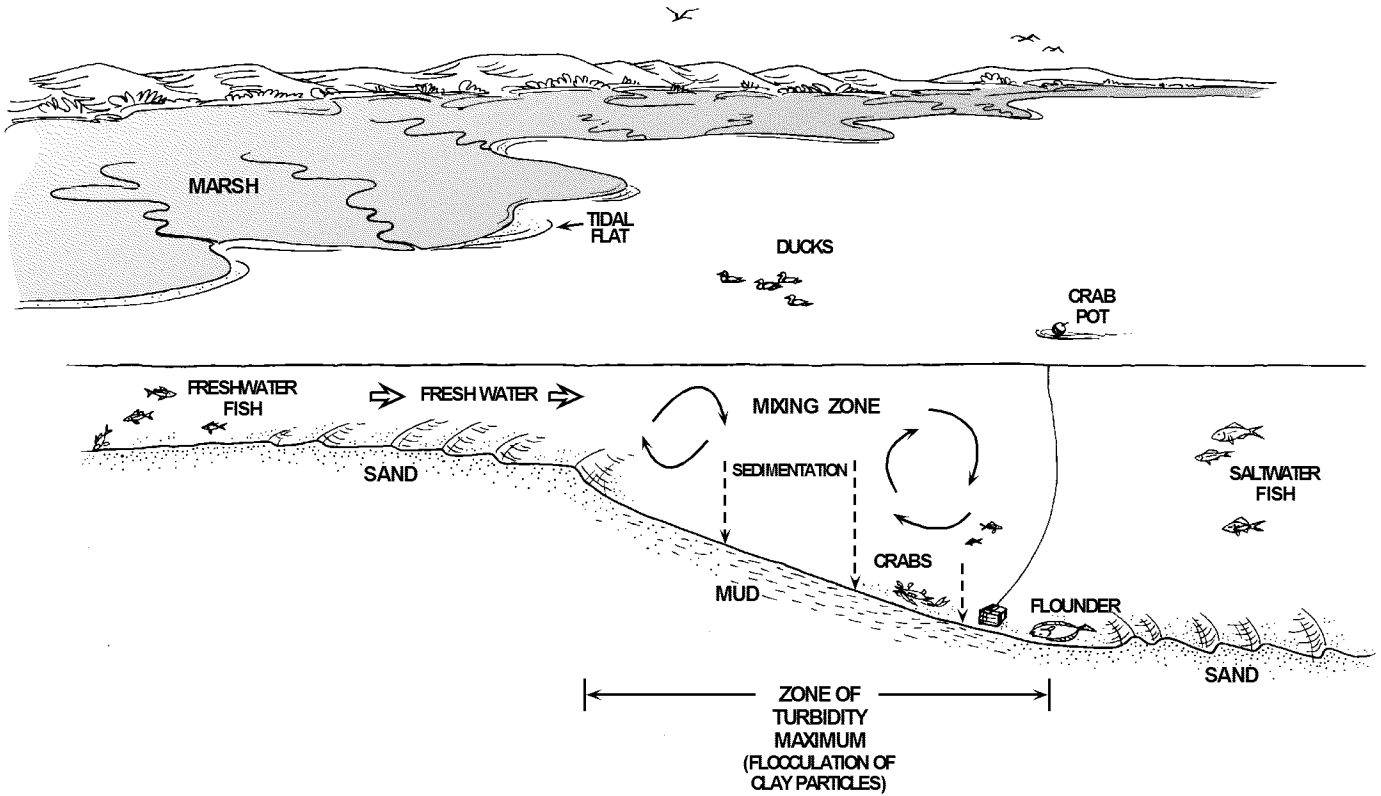
	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	A	B	B	B
Booming-Containment	–	A	A	A	–
Booming-Deflection/Exclusion	A	A	A	A	–
Skimming	–	A	A	A	–
Physical Herding	B	B	B	B	–
Manual Oil Removal/Cleaning	–	–	–	–	–
Sorbents	–	B	B	B	–
Debris Removal	–	A	A	A	–
Dispersants	B	A	A	A	–
Emulsion-treating Agents	–	B	B	B	–
Elasticity Modifiers	–	B	B	–	–
Herding Agents	–	B	B	–	–
Solidifiers	–	B	B	–	–
In-situ Burning	–	A	A	A	–


MARSH
TIDAL FLAT
DUCKS
CRAB POT
FRESHWATER FISH
FRESH WATER
MIXING ZONE
SEDIMENTATION
SAND
SALTWATER FISH
CRABS
MUD
FLOUNDER
SAND
ZONE OF TURBIDITY MAXIMUM (FLOCCULATION OF CLAY PARTICLES)

ON-WATER: Bays and estuaries

Description

- Near coastal waters partially surrounded by land and more sheltered than offshore habitats.
- Limited circulation and flushing, with depths frequently <30 feet.
- Suspended sediment concentrations can be high.
- Highly sensitive to oil spills, particularly where flushing rates are low and the probability of contact increases.
- Many species spawn in these habitats during spring, and their sensitive early life stages can persist in shallow waters.
- Large numbers of migratory or wintering waterfowl, wading, and diving birds are often found here. Bays and estuaries are also home to marine mammals and sea turtles.
- Estuaries and bays are used by commercially or recreationally important finfish, shellfish, and other organisms that migrate seasonally.

Predicted Oil Behavior

- Oil can impact bottom habitats (benthic organisms) when water is shallow.
- Stranded oil on nearby shorelines can become a prolonged source for oil re-released to the water column.
- Tides and fresh water can substantially influence spilled oil movement.

Response Considerations

- Reducing impacts to organisms that live on or in the sea surface is often a high priority.
- Reducing the extent of impacts to sensitive nearshore subtidal or intertidal habitats should be considered.
- Spill response is not conducted from a shoreline, but from water-based vessels or aircraft.
- Use of certain response options is seasonally limited to protect species with sensitive life histories.
- Adverse effects to birds would be greatest during migration and overwintering when the birds form large flocks.

Oil Category Descriptions

I – Gasoline products
II – Diesel-like products and light crudes
III – Medium grade crudes and intermediate products
IV – Heavy crudes and residual products
V – Non-floating oil products

The following categories are used to compare the relative environmental impact of each response method in the specific environment and habitat for each oil type. The codes in each table mean:

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– = Not applicable.

	Oil Category				
Response Method	**I**	**II**	**III**	**IV**	**V**
Natural Recovery	A	B	B	C	C
Booming-Containment	–	A	A	B	–
Booming-Deflection/Exclusion	A	A	A	B	–
Skimming	–	A	A	A	–
Physical Herding	B	B	B	B	–
Manual Oil Removal/Cleaning	–	–	C	B	B
Sorbents	–	B	B	B	–
Debris Removal	–	A	A	A	B
Dispersants	B	B	B	B	–
Emulsion-treating Agents	–	B	B	B	–
Elasticity Modifiers	–	B	B	–	–
Herding Agents	–	B	B	–	–
Solidifiers	–	B	B	–	–
In-situ Burning	–	A	A	B	–

U.S. Department of Commerce

National Oceanic and Atmospheric Administration

U.S. Department of Commerce
Vacant, Secretary

National Oceanic and Atmospheric Administration
Dr. Kathryn Sullivan, Acting Under Secretary of Commerce
for Oceans and Atmosphere and NOAA Administrator

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Dr. Holly Bamford, Assistant Administrator
for Ocean Services and Coastal Zone Management

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